FINAL REPORT
AUGUST 1991

REPORT NO. 92-12

U.S. ARMY NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER (NRDEC) SOLAR RADIATION TESTS ON MILVAN SHIELDING

Prepared for:
U.S. Army Natick Research, Development and Engineering Center
ATTN: SATNC-USOS
Natick, MA 01760-5017

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VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT UNLIMITED
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 92-12	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Defense Ammunition Center and School 6b. OFFICE SYMBOL (if applicable) SMCAC-DEV	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) ATTN: SMCAC-DEV Savanna, IL 61074-9639	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Natick Research, Development and Engineering Center 8b. OFFICE SYMBOL (if applicable) SATNC-USOS	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) ATTN: SATNC-USOS Natick, MA 01760-5017	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
U.S. Army Natick Research, Development and Engineering Center (NRDEC) Solar Radiation Tests on MILVAN Shielding

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM ——— TO ———	1991 August	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by U.S. Army Natick Research, Development and Engineering Center (NRDEC) to conduct engineering tests on solar radiation covers that can be used over MILVANs to protect ammunition. These tests monitored interior and exterior temperatures of protected and unprotected MILVANs. Tests were conducted at USADACS, Savanna, IL, during the summer of 1991. Covers for testing were supplied by NRDEC as well as Colebrand Limited. Several of these covers (tarpaulins) were very effective at reducing the effects of solar radiation and temperatures within MILVANs. This report contains the results of these tests.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
XX UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL JEROME H. KROHN	22b. TELEPHONE (Include Area Code) 815-273-8929	22c. OFFICE SYMBOL SMCAC-DEV

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. 92-12

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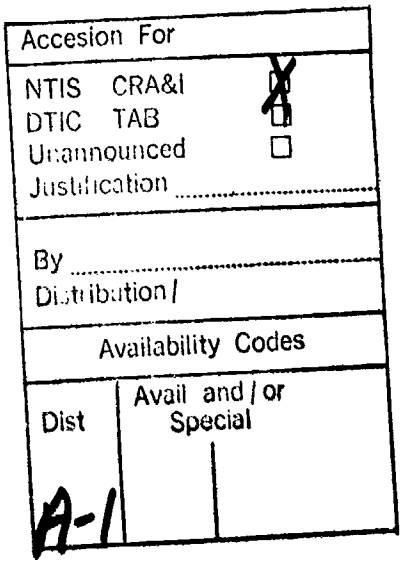

PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by U.S. Army Natick Research, Development and Engineering Center (NRDEC) to conduct engineering tests on solar radiation covers that can be used over MILVANs to protect ammunition. These tests monitored interior and exterior temperatures of protected and unprotected MILVANs. Tests were conducted at USADACS, Savanna, IL, during the summer of 1991. Covers for testing were supplied by NRDEC as well as Colebrand Limited.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of these tests was to determine the effectiveness of MILVAN solar radiation covers at protecting ammunition in openly stored MILVANs.

D. CONCLUSION. All tests conducted to date indicate that the NRDEC cover is slightly better at reducing MILVAN exterior temperatures and dissipating heat, while the Colebrand Limited cover resulted in slightly lower interior temperatures. The Colebrand Limited cover, although heavier, has several design advantages; i.e., shielded top and sides, easy access to MILVAN interior, material handling, transportability, and stackability of MILVANs with covers in place. The NRDEC design requires prepositioned MILVANs, prior to the tent (tarpaulin) installation using conventional poles, stakes, ropes, etc.

E. RECOMMENDATION. Due to the advantages of both designs, it is recommended that additional tests be conducted on second generation tarpaulins/covers incorporating qualities of each.

F. COMMENTS. Disassembly of Colebrand Limited cover proved to be difficult. The cover had absorbed moisture during rains, resulting in excess weight. The cover appeared to shrink, resulting in tarpaulin connectors being very hard to remove. The tarpaulin, although claiming to be waterproof, retained moisture and would have a short service life if fielded.

PART 2

JUNE - AUGUST 1991

ATTENDEES

William R. Meyer General Engineer DSN 585-8090 815-273-8090	Director U.S. Army Defense Ammunition Center and School ATTN: SMCAC-DEV Savanna, IL 61074-9639
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David V. Valant Electronics Technician DSN 585-8093 815-273-8093	Director U.S. Army Defense Ammunition Center and School ATTN: SMCAC-DEV Savanna, IL 61074-9639
Bill Mounts Sales Representative 703-521-5829	Colebrand USA Limited 1800 Diagonal Rd. Suite 600 Alexandria, VA 22314

PART 3

TEST PROCEDURES

MILVANs were loaded with inert ammunition to simulate "real world" open storage conditions. One MILVAN was unprotected and used as the control sample with two MILVANs covered with different types of tarpaulins and used as the test samples. Thermal couples were placed in all MILVANs at the following locations:

a. On the MILVAN roof (exterior).

b. MILVAN interior, four inches below the roof.

c. On top of the inert load.

d. In the center of the inert load.

e. On the bottom of the inert load.

Tables in Part 5 of this report contain weekly peak temperatures of the MILVAN roof and four inches below the roof, with the graphs in Part 6 containing the balance of the temperature data. During the test period, the MILVAN doors were closed. MILVAN temperature readings, including ambient and humidity, were recorded every five minutes throughout the two-month test period (see Part 6 for test setup).

PART4

TEST EQUIPMENT

A. TEST MILVAN CONTAINERS:

1. Quantity:	3
2. Type:	U.S. Air Force side-opening
3. Weight:	40,000 pounds (approximately)
4. Cube:	1,280 cubic feet

B. WEATHER STATION:

1. Manufacturer:	Climatronics
2. Number of Channels:	64
3. Type of Probe:	Thermocouple

C. DATA LOGGER:

1. Manufacturer:	Omega
2. Number of Channels:	8
3. Type of Probe:	Thermisters

PART 5

TEST RESULTS

TEST 1

The first series of tests was conducted with two NRDEC tarpaulins, one having a single layer open-mesh fabric and tan in color and referred to as NRDEC I. The second tarpaulin was identical to the first with the exception of a second layer of black open-mesh underlayment over the MILVAN roof to provide for greater solar radiation protection and referred to as NRDEC II.

This test lasted two months with data compiled into weekly summaries for peak weekly maximum temperatures (Tables 1 and 3) and average daily high temperatures(Tables 2 and 4). Temperature readings within this report are for ambient, the MILVAN roof, and four inches from the roof on the inside of the MILVAN.

TABLE 1

Test 1

NRDEC MILVAN Tarpaulins I and II
Peak Weekly Temperatures (degrees Fahrenheit)

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down
5-12 Jun 91	Control	90.3	155.1	131.1
	NRDEC I		126.2	110.3
	NRDEC II		100.8	91.7
13-20 Jun 91	Control	89.9	137.3	129.0
	NRDEC I		120.5	108.3
	NRDEC II		103.8	92.3
21-26 Jun 91	Control	93.2	137.1	122.2
	NRDEC I		115.9	91.8
	NRDEC II		95.4	96.2

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down
26-30 Jun 91	Control	95.3	134.3	125.5
	NRDEC I		120.2	109.5
	NRDEC II		98.8	99.3
3-10 Jul 91	Control	94.0	136.6	124.9
	NRDEC I		119.9	108.4
	NRDEC II		96.9	96.7
10-17 Jul 91	Control	96.4	138.8	122.9
	NRDEC I		97.4	98.1
	NRDEC II		96.9	96.7
17-24 Jul 91	Control	97.3	134.8	127.0
	NRDEC I		120.6	110.5
	NRDEC II		99.0	103.3
24-31 Jul 91	Control	96.9	138.4	125.8
	NRDEC I		116.9	107.0
	NRDEC II		98.6	98.4
1-7 Aug 91	Control	95.1	125.4	113.3
	NRDEC I		106.9	103.3
	NRDEC II		96.4	96.9

During this phase of testing, the maximum temperature on the MILVAN control roof reached 155.1 degrees Fahrenheit during the week of 6 June 1991. The NRDEC I MILVAN was 126.1 degrees Fahrenheit, while the NRDEC II MILVAN only reached 100.8 degrees Fahrenheit or (10.5 degrees over ambient temperature). On the average, the NRDEC I tarpaulin reduced MILVAN peak roof temperatures by 14 percent from 137.4 to 118.3 degrees Fahrenheit with average MILVAN roof peak temperature over average ambient by 25.5 percent, 94.3 versus 118.3 degrees Fahrenheit. The NRDEC II design, on the other hand, reduced average MILVAN roof temperatures by 28.2 percent from 137.4 to 98.6 degrees Fahrenheit with average

MILVAN roof peak temperatures over ambient of only 4.3 degrees, 94.3 versus 98.6 degrees Fahrenheit. Inside the MILVAN, four inches below the MILVAN roof, the control MILVAN had average peak temperatures of 124.6 versus 106.3 degrees Fahrenheit for NRDEC I and 97.0 degrees Fahrenheit for NRDEC II. For the NRDEC II tarpaulin at four inches below the MILVAN roof, the average temperature was only 2.7 degrees above ambient.

Data from the first test were also compiled using the average daily high temperatures during the test period. This data may be more useful in determining tarpaulin effectiveness than peak temperatures reported in Table 1. Data reported within Table 2 were compiled by summing daily high temperatures and averaging over the week.

TABLE 2

Test 1

NRDEC MILVAN tarpaulins I and II
Average Daily High Temperatures

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down
5-12 Jun 91	Control	86.9	137.3	120.9
	NRDEC I		113.7	102.6
	NRDEC II		93.4	87.3
13-20 Jun 91	Control	85.9	137.1	119.4
	NRDEC I		113.6	102.0
	NRDEC II		96.1	88.1
21-26 Jun 91	Control	85.1	120.5	111.3
	NRDEC I		104.7	85.6
	NRDEC II		87.6	89.1

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down
26-30 Jun 91	Control	89.2	114.7	109.8
	NRDEC I		105.4	100.1
	NRDEC II		91.1	92.6
3-10 Jul 91	Control	87.9	130.3	118.5
	NRDEC I		113.2	102.7
	NRDEC II		91.3	91.9
10-17 Jul 91	Control	88.3	126.6	116.7
	NRDEC I		110.2	101.0
	NRDEC II		91.0	92.2
17-24 Jul 91	Control	87.0	128.0	118.4
	NRDEC I		112.9	102.0
	NRDEC II		90.8	92.0
24-31 Jul 91	Control	85.2	123.0	113.6
	NRDEC I		106.4	97.6
	NRDEC II		88.0	89.2
1-7 Aug 91	Control	80.1	113.1	105.2
	NRDEC I		98.0	91.3
	NRDEC II		83.9	84.4

In summary, the average daily high temperature on the control MILVAN roof was 125.6 degrees Fahrenheit with maximum temperatures reaching 137.1 degrees Fahrenheit during the week of 6 June 1991. The NRDEC I MILVAN had an average daily high temperature of 108.7 degrees Fahrenheit while the NRDEC II MILVAN only reached 90.4 degrees Fahrenheit (or 4.2 degrees over ambient temperature; i.e., 86.2 versus 90.4 degrees Fahrenheit). On the average, the NRDEC I tarpaulin reduced MILVAN roof temperatures by 13.5 percent with MILVAN roof temperatures under the NRDEC I 22.5 degrees Fahrenheit over ambient. The NRDEC II design, on the other hand, reduced average daily MILVAN roof temperatures by

28 percent with these temperatures exceeding average daily ambient temperatures by 4.2 degrees. Inside the MILVAN, four inches below the MILVAN roof, the control MILVAN had an average daily high temperature of 114.9 degrees Fahrenheit versus 98.3 degrees Fahrenheit for NRDEC I, and 89.6 degrees Fahrenheit for NRDEC II.

TEST 2

A second series of tests was conducted with the NRDEC II tarpaulin, due to its superior performance, and MILVAN solar radiation blanket supplied by Colebrand Limited. The Colebrand Limited design included multi-layers of material sewn together with a waterproof exterior and fasteners that allowed the ends and sides of the blanket to be opened for access to the container doors without removal of the cover required with the NRDEC designs. This blanket could also remain in place over the MILVAN, protecting the ammunition during shipment.

TABLE 3

Test 2

NRDEC MILVAN tarpaulin II
Versus Colebrand Limited Thermal Cover
Peak Temperature Readings

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down	Top Load
10-11 Aug 91	Control	87.1	133.3	118.9	109.5
	Colebrand		99.8	91.0	80.0
	NRDEC II		90.0	89.4	84.6
11-14 Aug 91	Control	86.5	133.2	121.7	113.2
	Colebrand		99.7	93.5	81.3
	NRDEC II		90.3	90.6	87.2

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down	Top Load
14-21 Aug 91	Control	86.4	129.3	119.6	111.6
	Colebrand		97.4	92.0	80.8
	NRDEC II		91.5	93.2	89.3
21-28 Aug 91	Control	94.1	133.1	123.1	116.5
	Colebrand		100.1	95.9	85.5
	NRDEC II		95.6	95.8	92.6
28 Aug - 4 Sep 91	Control	89.3	127.5	117.5	109.5
	Colebrand		92.9	88.6	83.2
	NRDEC II		90.9	92.6	89.0
4-11 Sep 91	Control	89.8	132.5	120.7	112.8
	Colebrand		93.2	89.3	77.9
	NRDEC II		91.2	91.5	87.1

During peak daylight hours, the NRDEC covered MILVAN was approximately 5 degrees cooler than the Colebrand Limited MILVAN. For example, on 22 August 1991 with ambient temperature at 85 degrees Fahrenheit, the MILVAN roofs reached the following temperatures: unprotected (control) MILVAN, 130 degrees Fahrenheit; Colebrand Limited MILVAN, 95 degrees Fahrenheit; and the NRDEC MILVAN, 90 degrees Fahrenheit. On the Colebrand Limited MILVAN, temperatures at the top of the load were approximately 7 degrees lower than the NRDEC II tarpaulin and thought to be due to the thermal insulating properties of the Colebrand Limited tarpaulin.

TABLE 4

Test 2

NRDEC MILVAN tarpaulin II
Versus Colebrand Limited Thermal Cover
Average Daily High Temperatures

Test Date	Test Sample	Ambient Temp.	MILVAN Roof	Inside 4 Inches Down	Top Load
10-11 Aug 91	Control	74.4	101.4	95.4	89.7
	Colebrand		83.4	81.4	77.5
	NRDEC II		77.5	79.5	76.6
11-14 Aug 91	Control	82.3	118.5	110.3	104.3
	Colebrand		93.4	88.9	79.8
	NRDEC II		86.3	87.0	83.9
14-21 Aug 91	Control	79.8	113.4	106.8	100.2
	Colebrand		86.7	83.7	77.2
	NRDEC II		83.1	85.0	81.6
21-28 Aug 91	Control	89.4	121.5	113.4	107.6
	Colebrand		94.6	91.8	83.2
	NRDEC II		91.0	91.7	89.0
28 Aug - 4 Sep 91	Control	83.2	118.0	111.0	104.2
	Colebrand		88.4	85.8	77.8
	NRDEC II		85.8	87.4	83.8
4-11 Sep 91	Control	83.2	114.6	107.9	101.4
	Colebrand		86.2	83.6	76.0
	NRDEC II		85.7	86.7	82.9

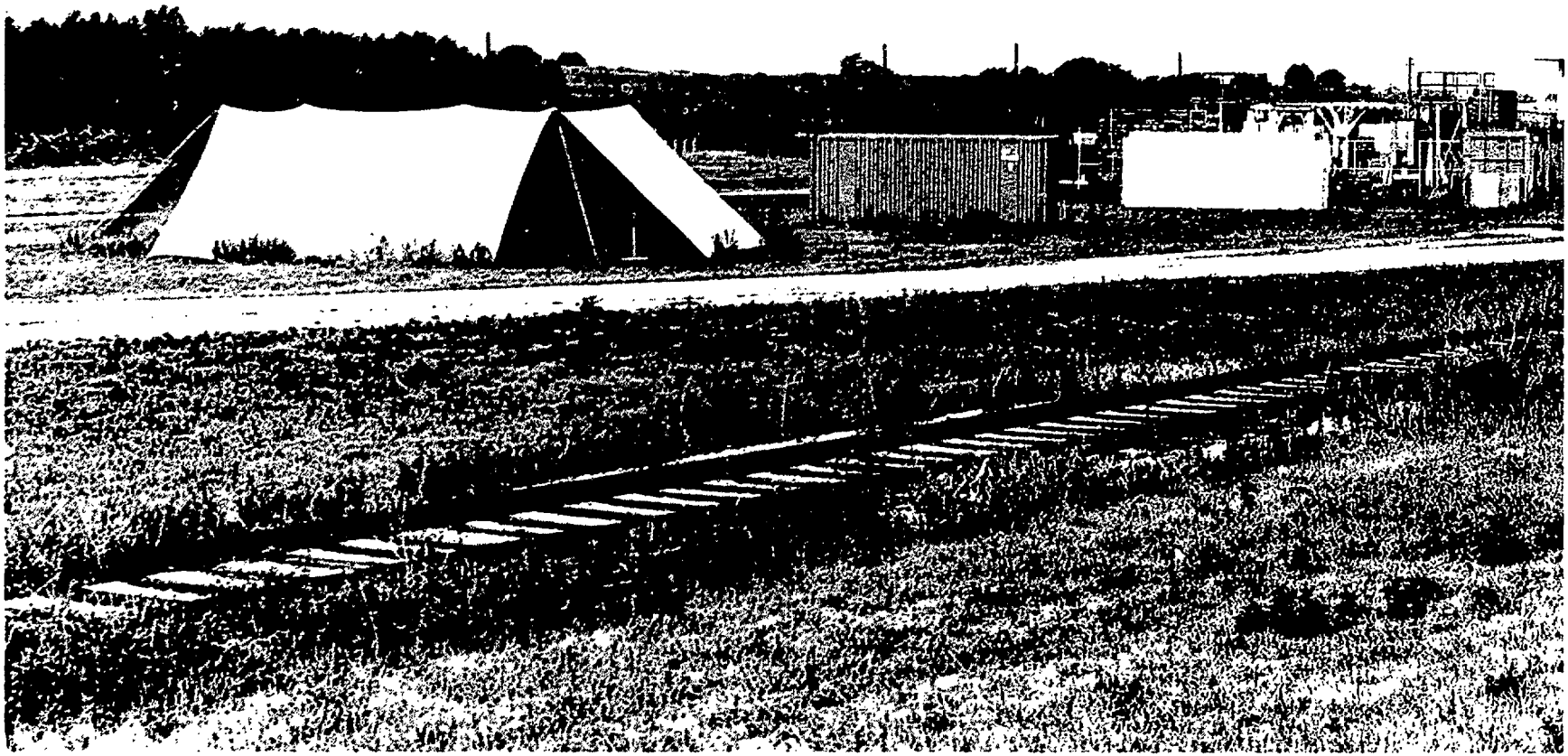
Typical trends for average daily high temperatures for the test samples were as follows. The NRDEC II MILVAN had slightly lower roof temperatures, with interior temperatures

slightly higher than the Colebrand Limited sample. The top of the test load for the Colebrand Limited MILVAN was approximately 4 degrees cooler than the NRDEC II MILVAN, similar to what is shown in Table 3.

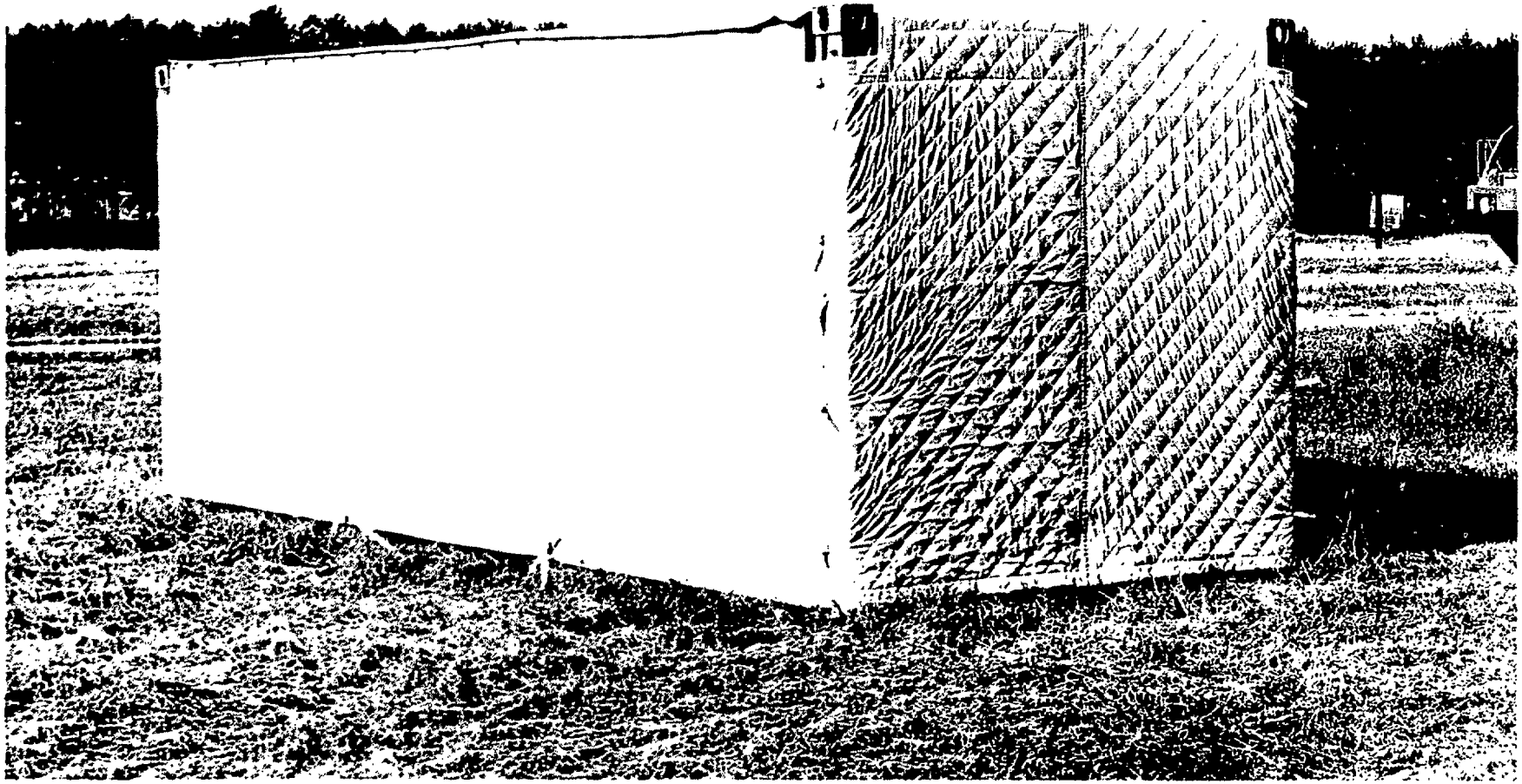
PART 6

PHOTOGRAPHS

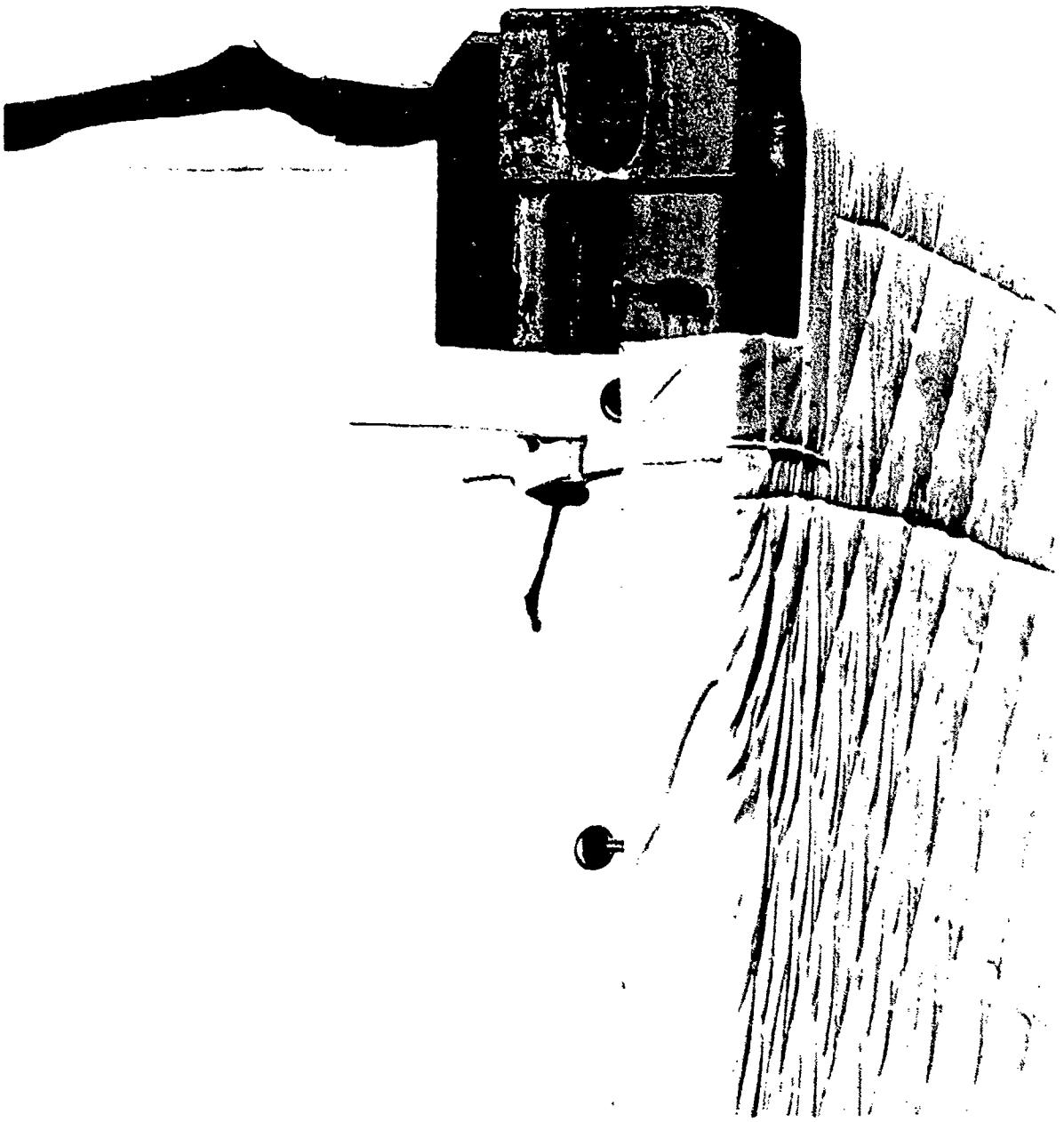
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
Photo No. AO317-SCN91-298-2321. This photo shows an overall view of the test setup with U.S. Army Natick Research, Development and Engineering Center (NRDEC) tarpaulins.		



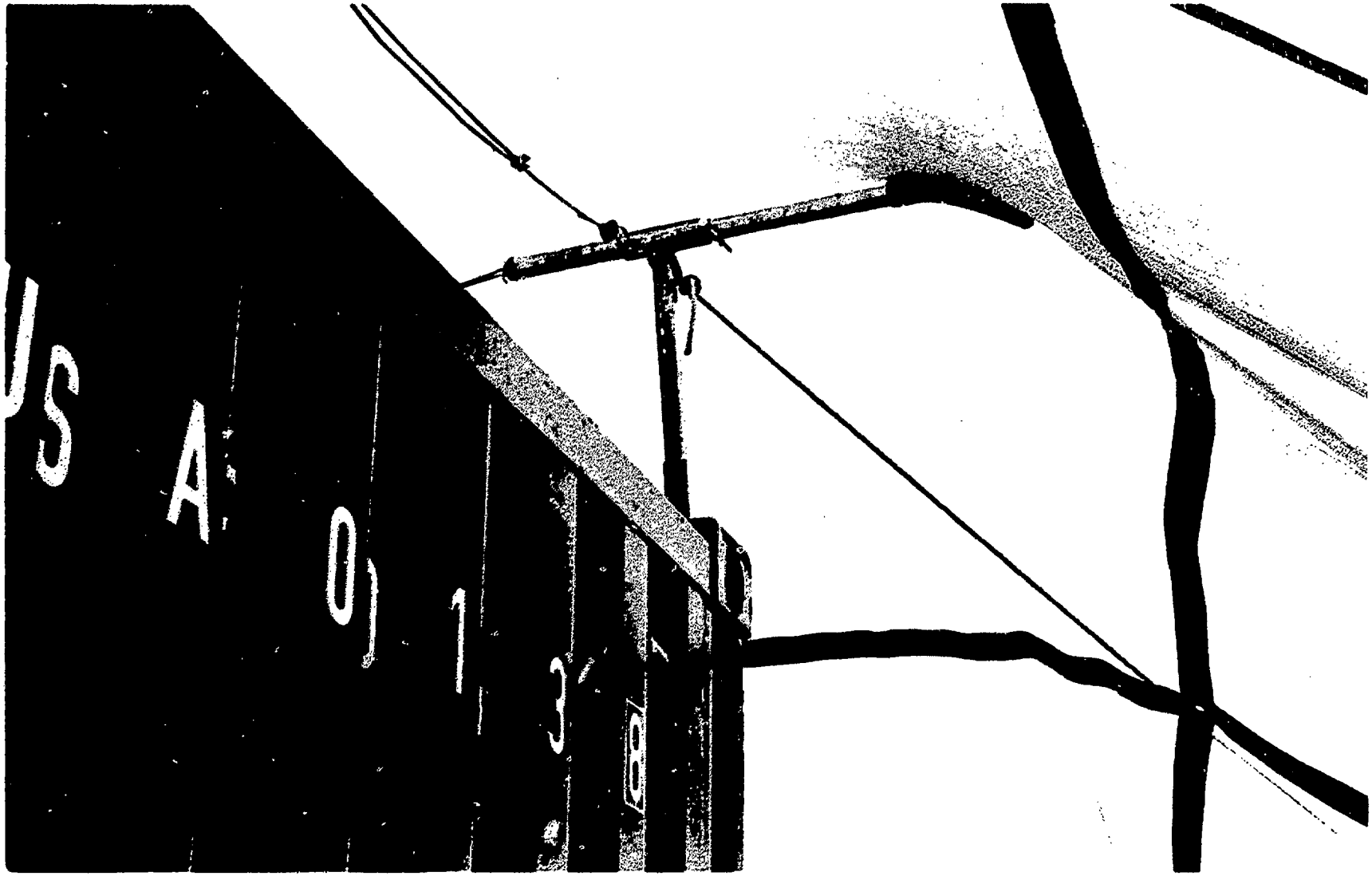
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
Photo No. AO317-SCN91-298-4906. This photo shows an overall view of the test setup. Note: the Colebrand Limited tarpaulin in the background.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
Photo No. AO317-SCN91-298-4904. This photo shows a closeup view of the Colebrand Limited tarpaulin.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
Photo No. AO317-SCN91-298-4917. This photo shows the Colebrand Limited tarpaulin with a closeup view of the International Organization for Standardization (ISO) corner fitting for container handling of the MILVAN with tarpaulin installed.		

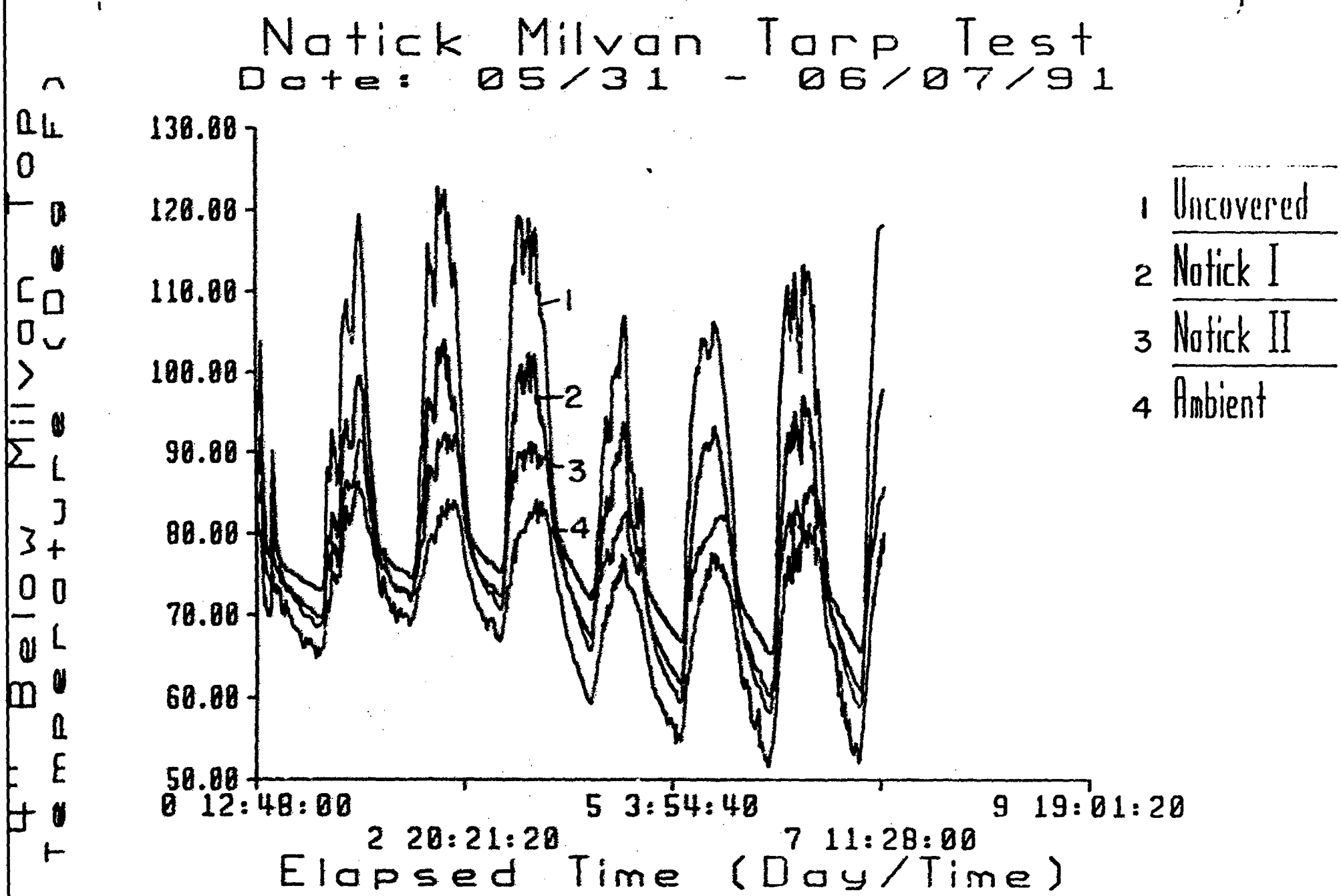


	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	

Photo No. AO317-SCN91-298-2334 This photo shows a closeup view of an alternative tarpaulin support system provided by American Nurseries which was inadequate for its intended purpose due to the weak mechanical design.

PART 7

GRAPHS


Natick Milvan Tarp Test
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4 Below Milvan Tarp
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
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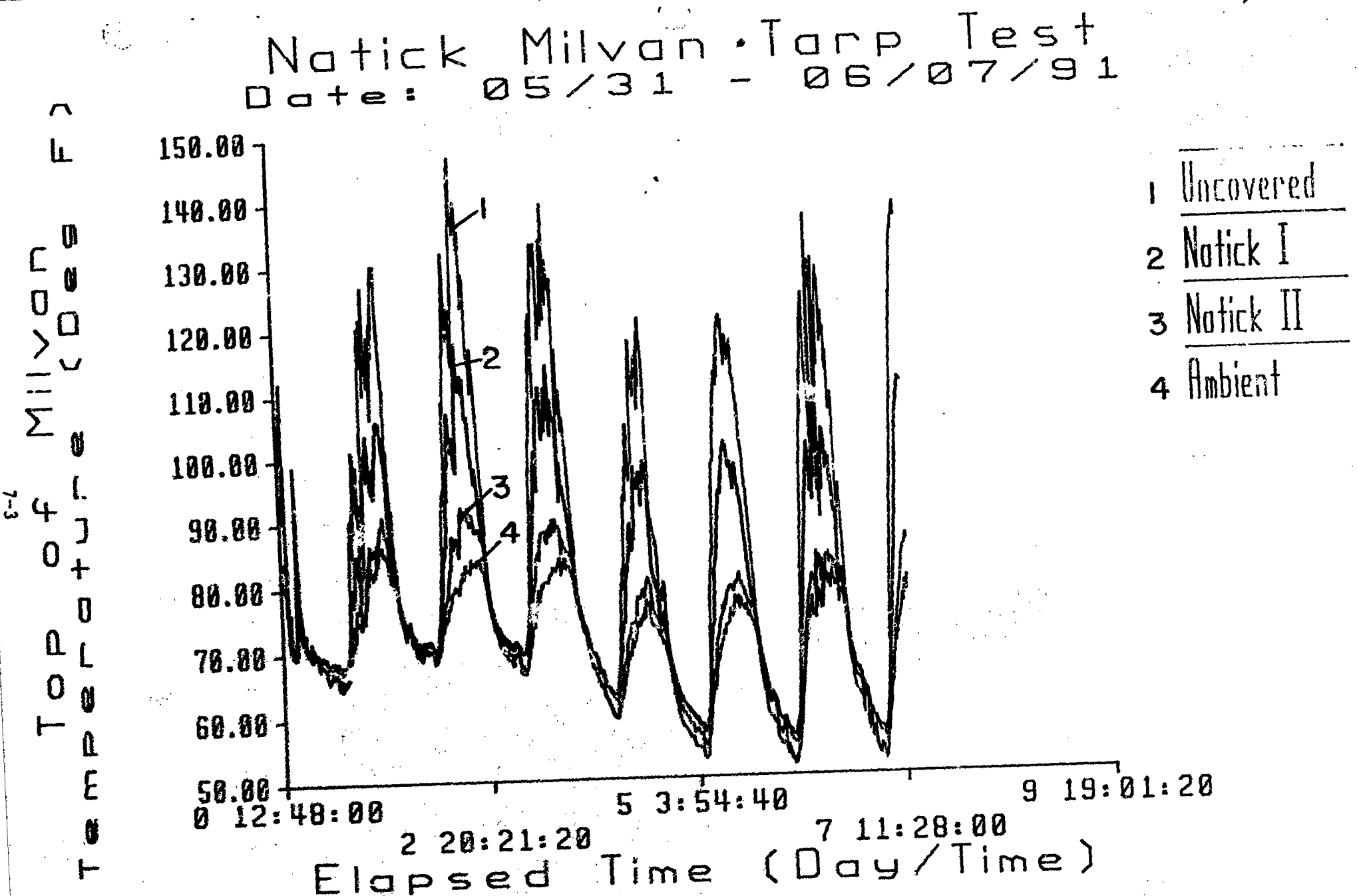
Elapsed Time (Day/Time)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Milvan Top of Tarp Temperature (F)
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140.00
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120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
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5 3:54:40
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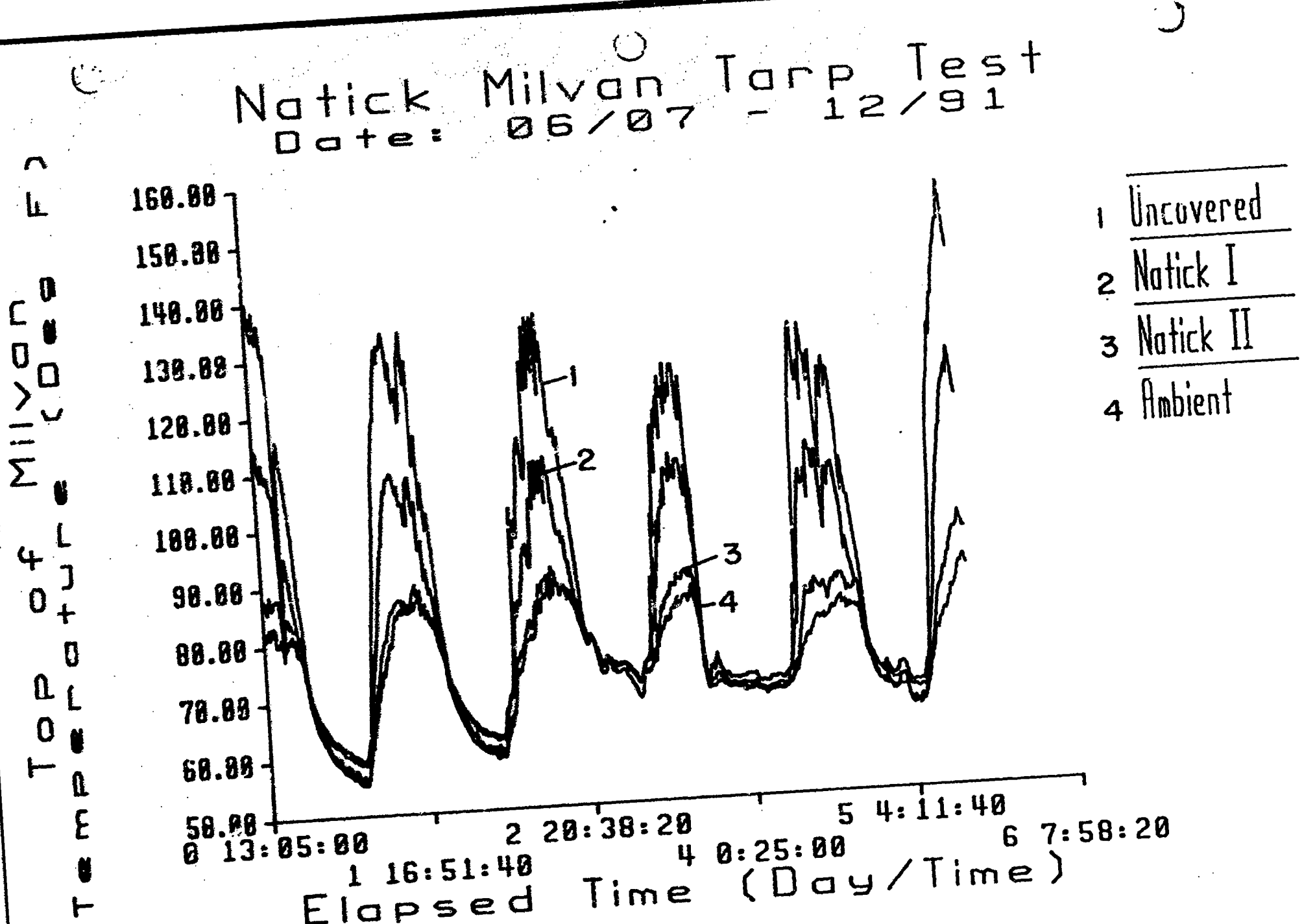
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Top of Milvan Temperature (F)
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90.00
80.00
70.00
60.00
50.00
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2 Natick I
3 Natick II
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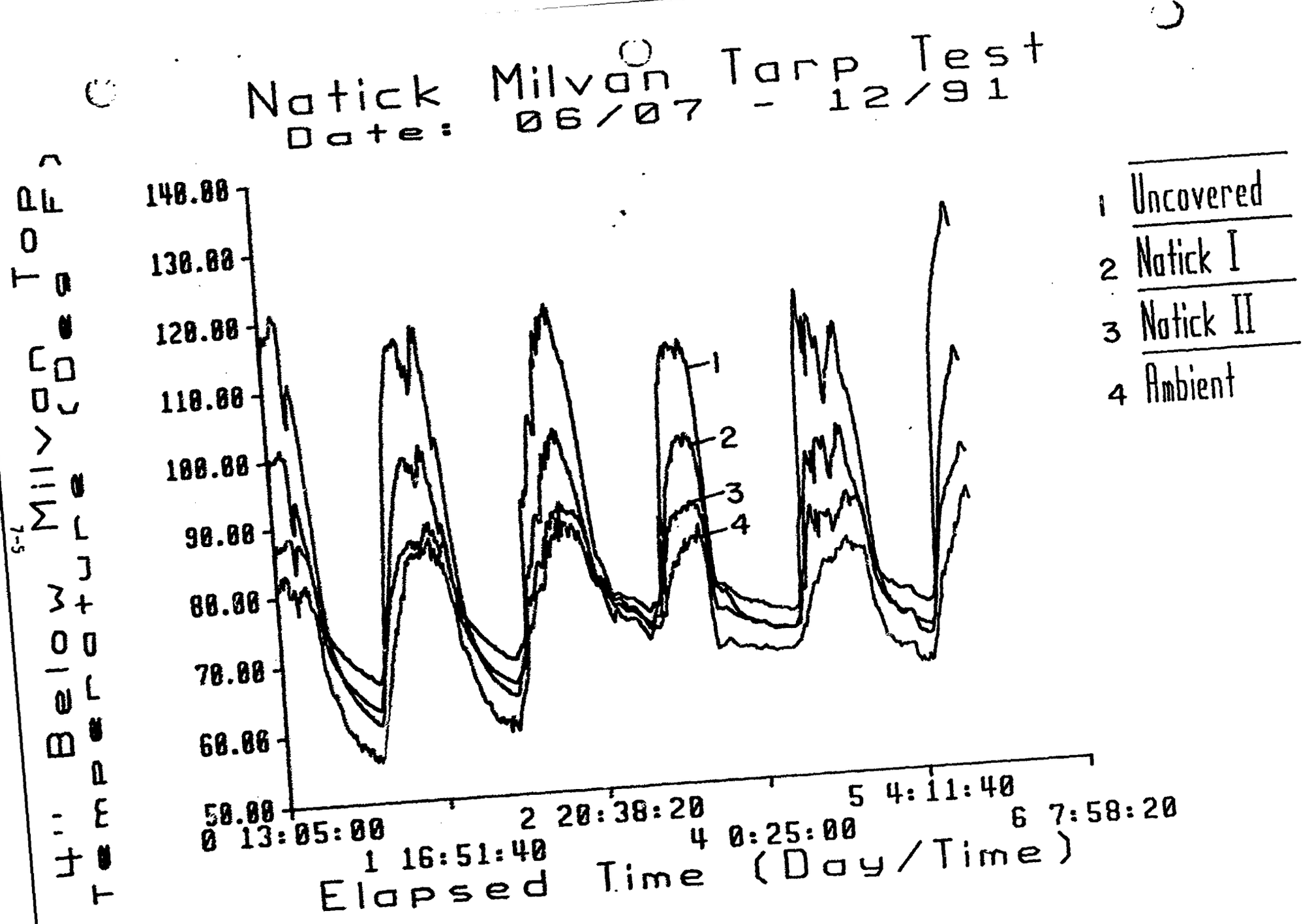
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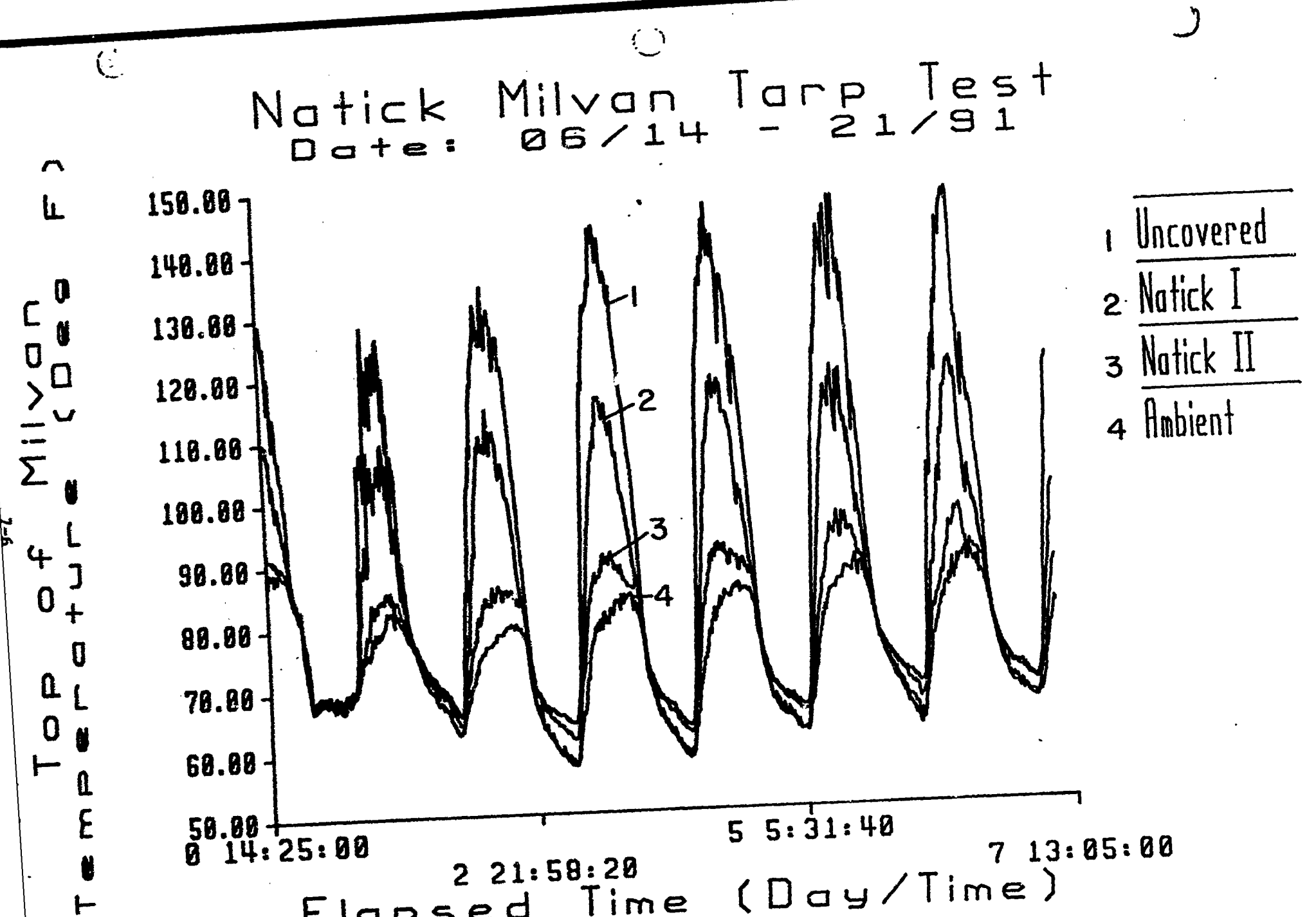
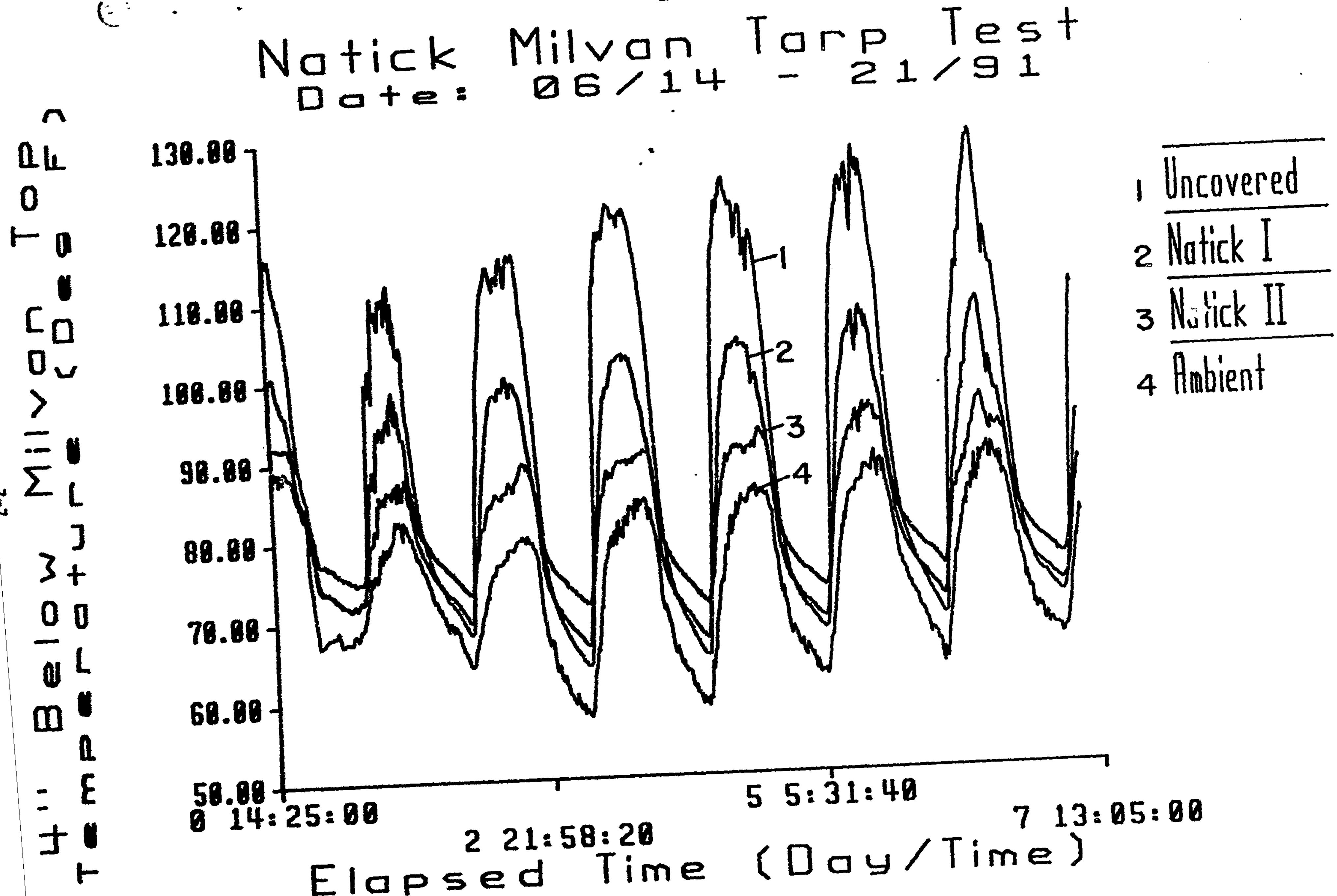
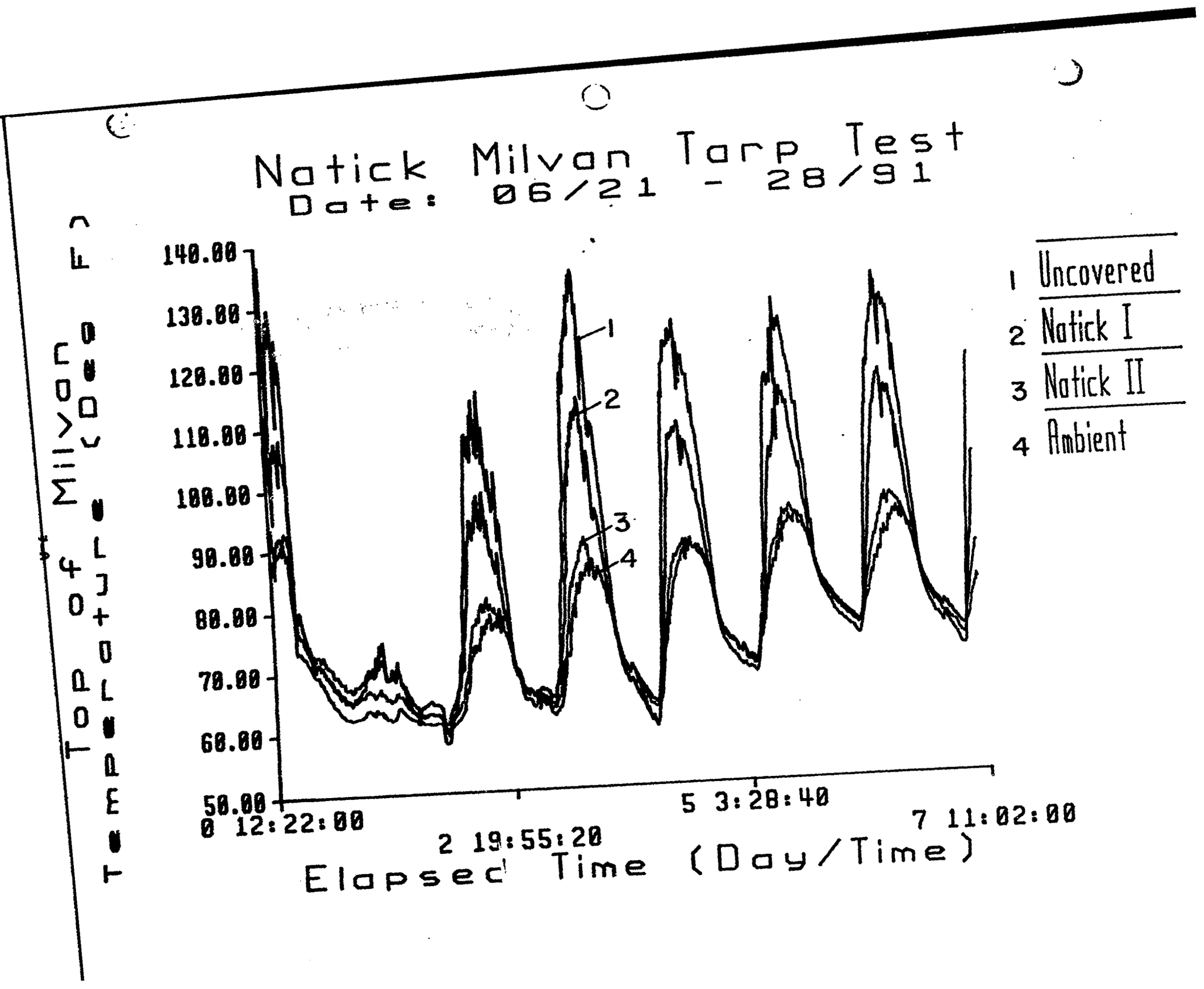
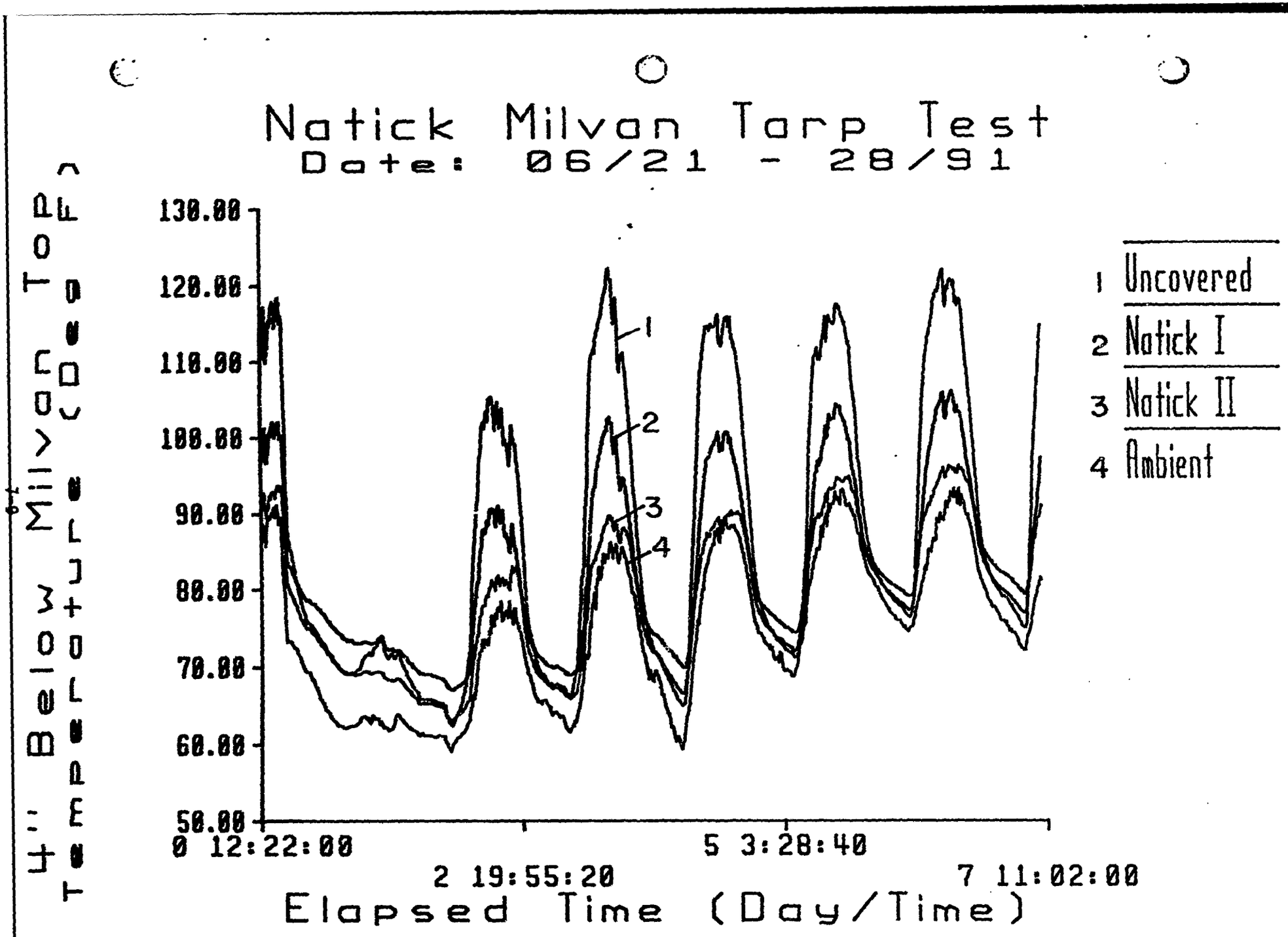
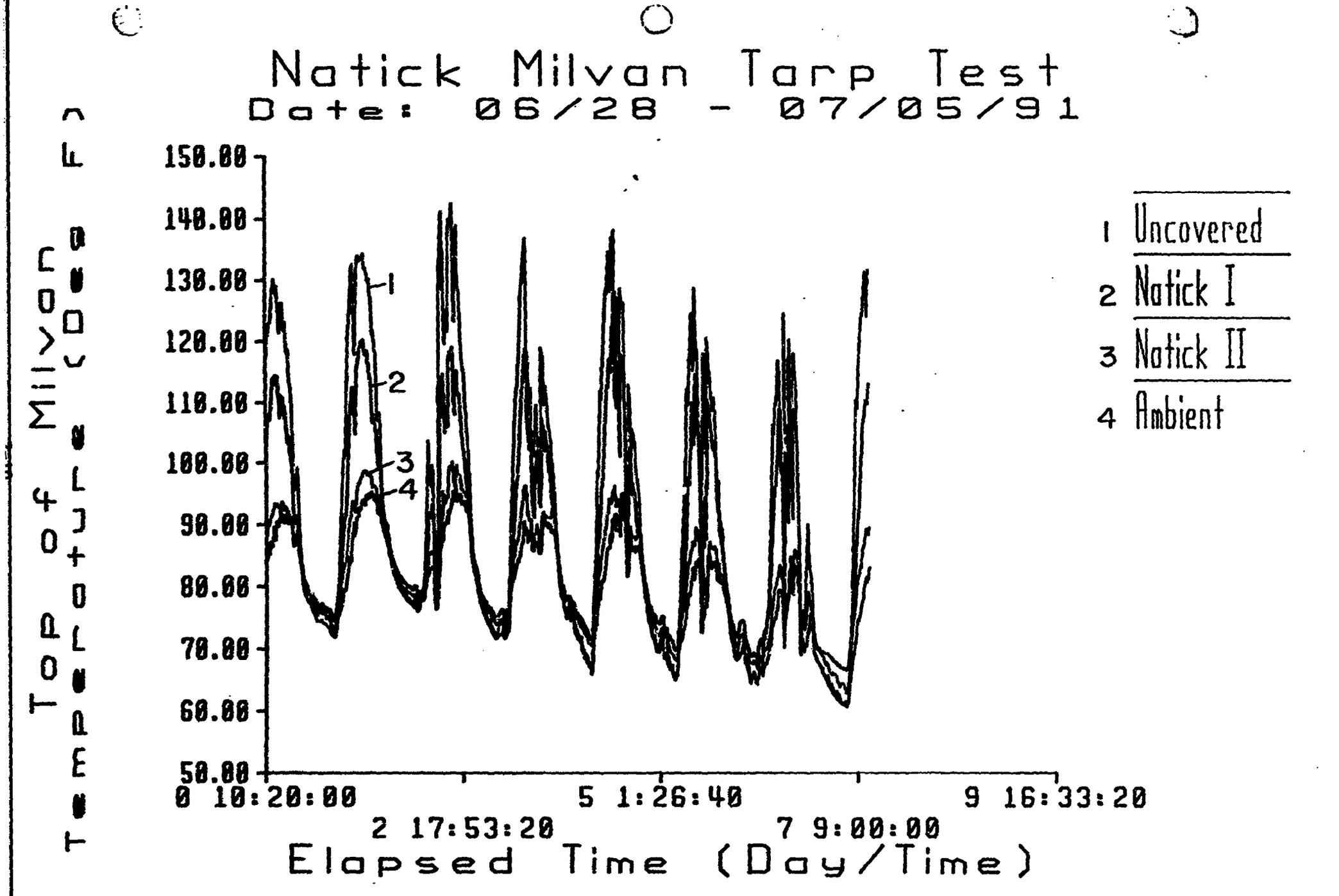
60.00
50.00
0 13:05:00
1 16:51:40
2 20:38:20
4 0:25:00
5 4:11:40
6 7:58:20
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
1
2
3
4

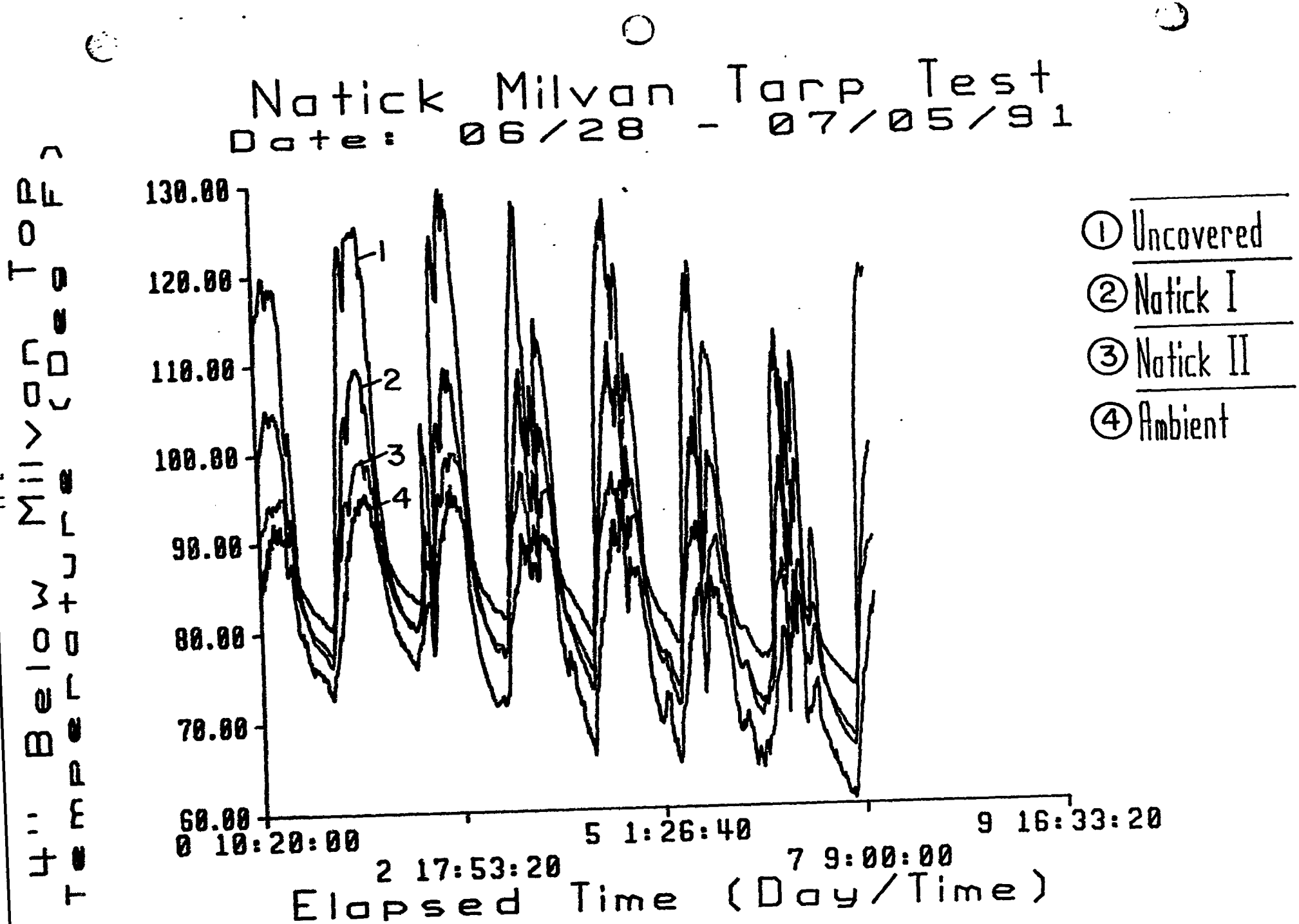

Natick Milvan Tarp Test
Date: 06/14 - 21/91
Top of Milvan Temperature (Deg F)
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 14:25:00
2 21:58:20
5 5:31:40
7 13:05:00
Elapsed Time (Day/Time)

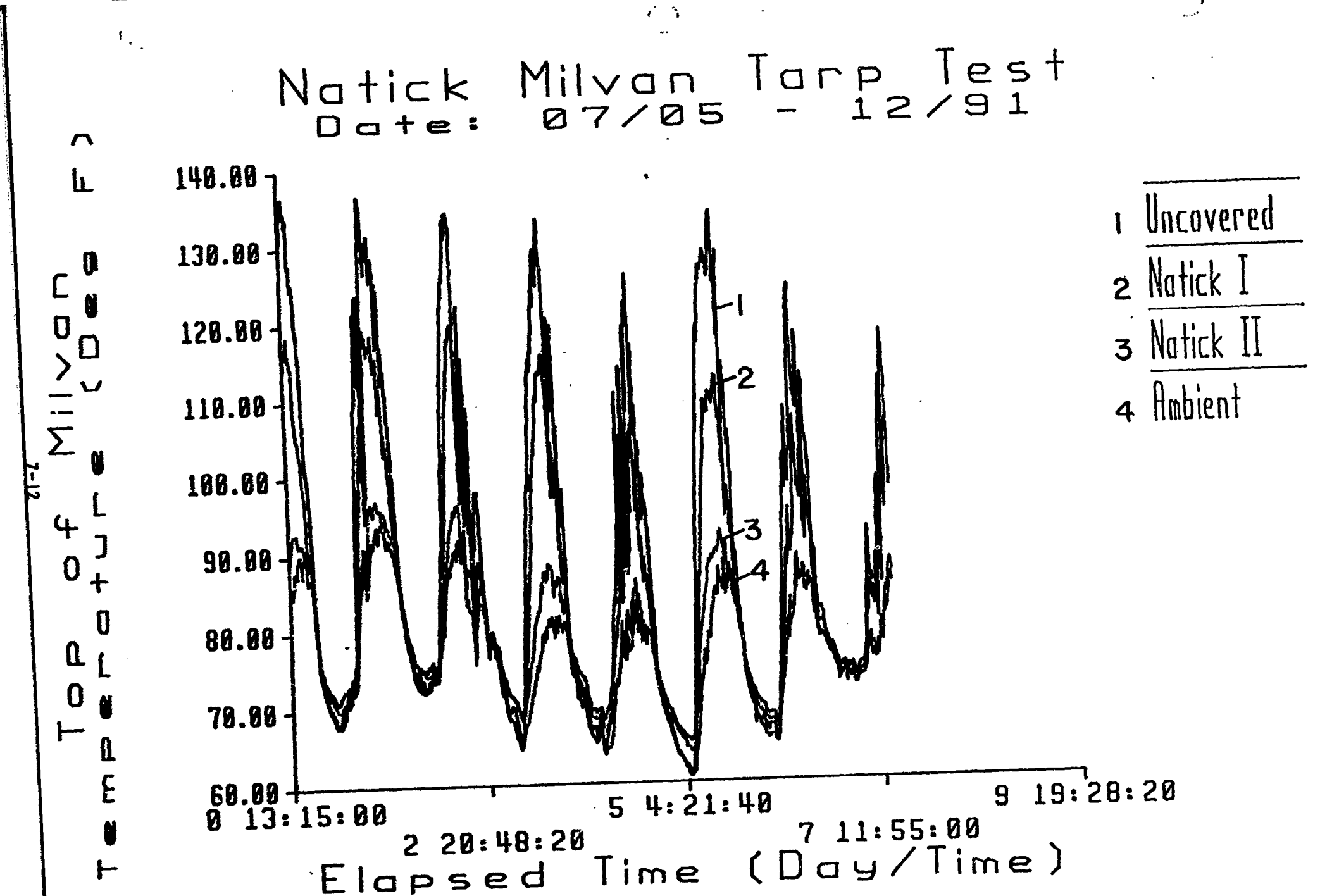

Natick Milvan Tarp Test
Date: 06/14 - 21/91
Temperature Below Milvan Top (°F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 14:25:00
2 21:58:20
5 5:31:40
7 13:05:00
Elapsed Time (Day/Time)
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient

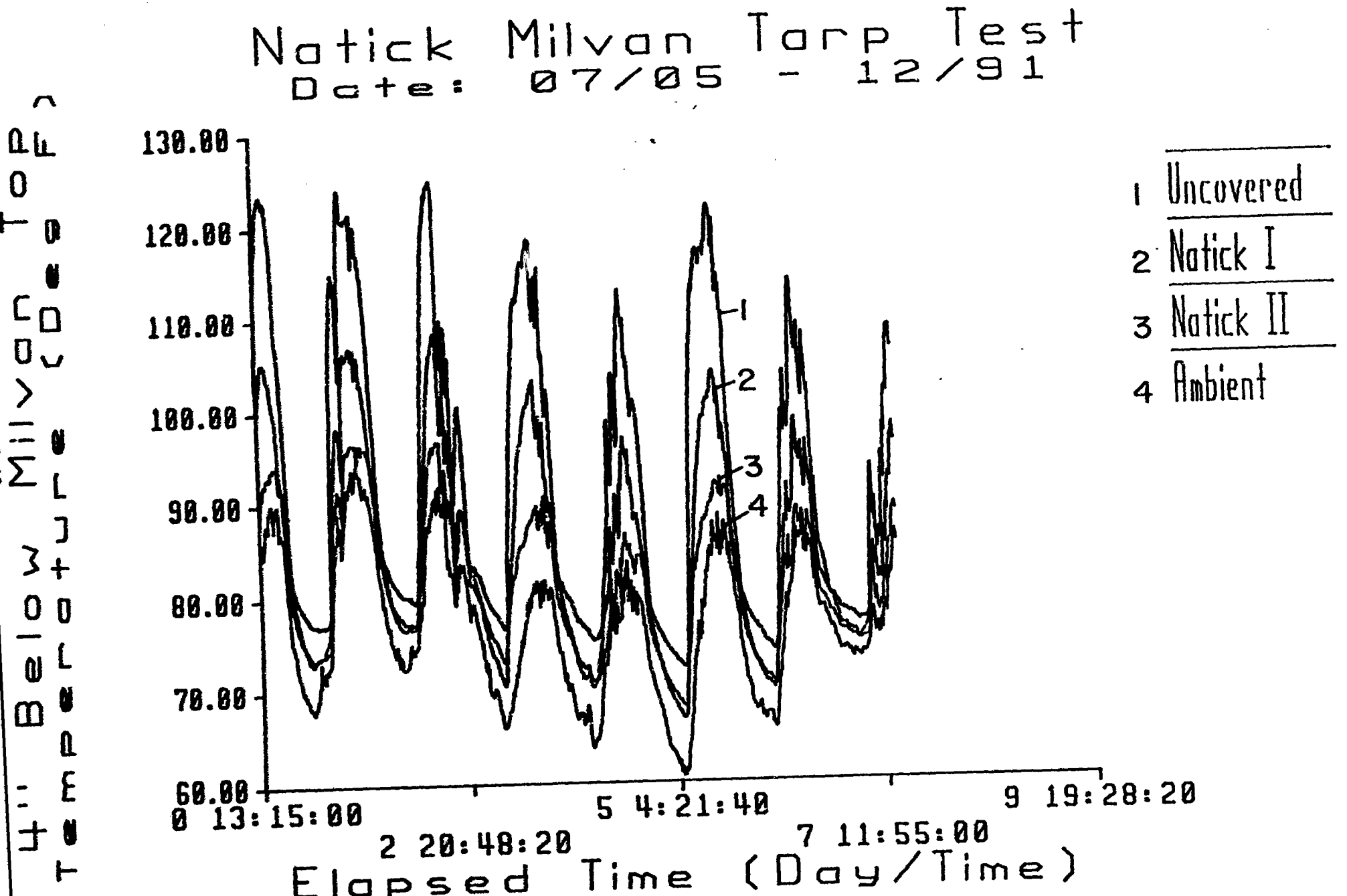

Natick Milvan Tarp Test
Date: 06/21 - 28/91
Top of Milvan Temperature (Deg F)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 12:22:00
2 19:55:20
5 3:28:40
7 11:02:00
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient

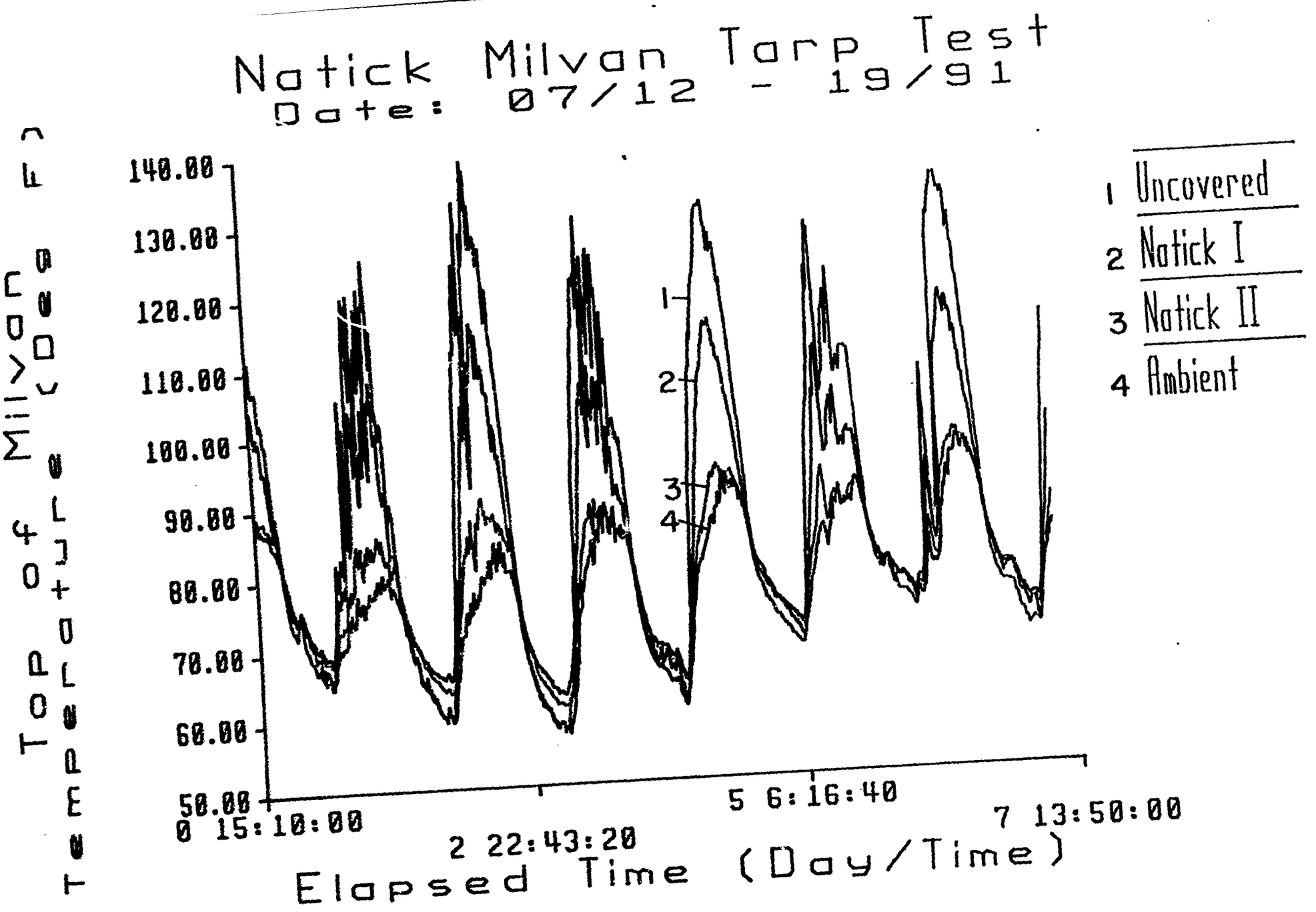

Natick Milvan Tarp Test
Date: 06/21 - 28/91
4" Below Milvan Top
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 12:22:00
2 19:55:20
5 3:28:40
7 11:02:00
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient

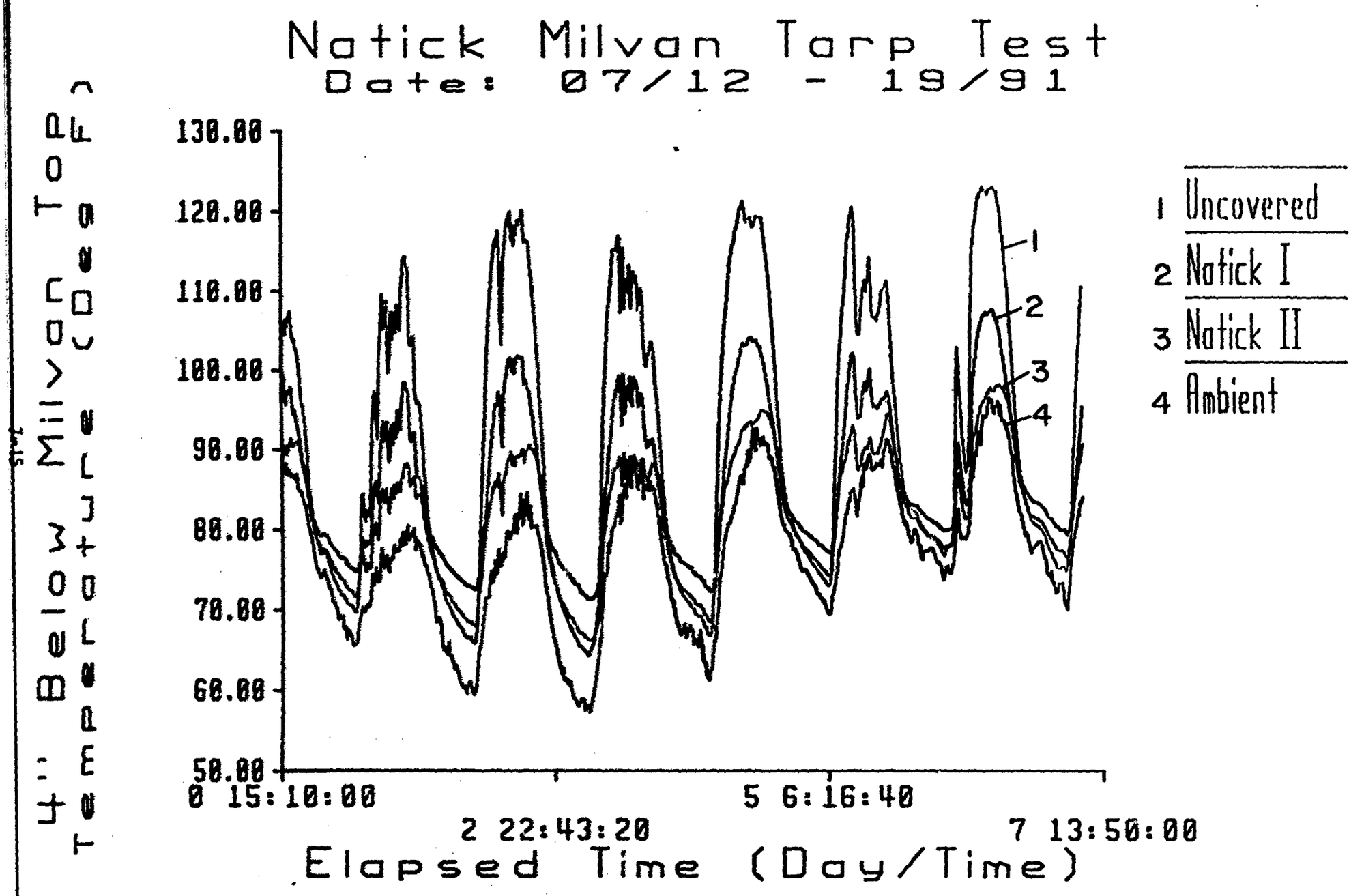

Natick Milvan Tarp Test
Date: 06/28 - 07/05/91
Top of Milvan Temperature (Deg F)
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
0 10:20:00
2 17:53:20
5 1:26:40
7 9:00:00
9 16:33:20
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient

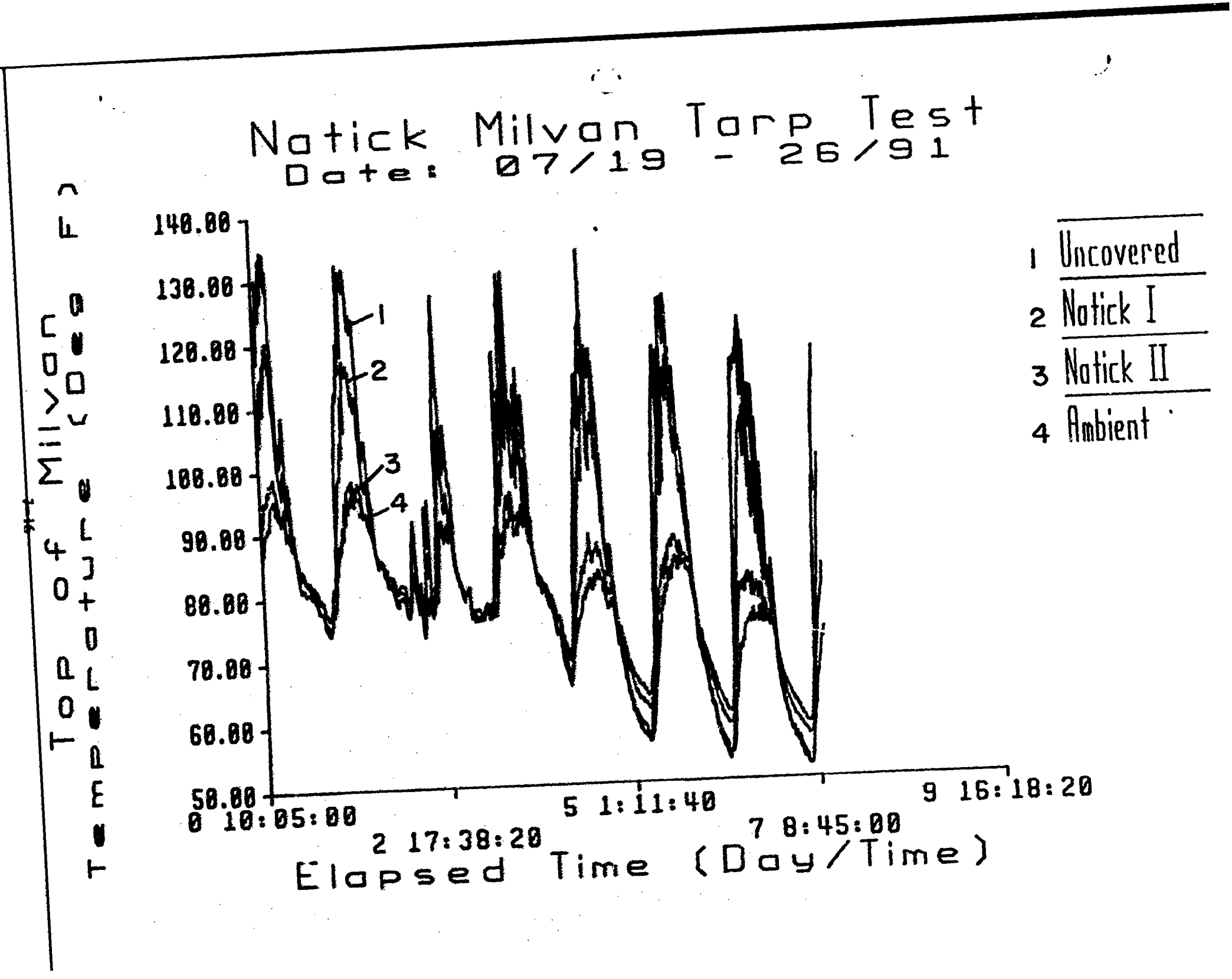

Natick Milvan Tarp Test
Date: 06/28 - 07/05/91
Temperature Below Milvan Tarp (F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
1
2
3
4
0 10:20:00
2 17:53:20
5 1:26:40
7 9:00:00
9 16:33:20
Elapsed Time (Day/Time)
① Uncovered
② Natick I
③ Natick II
④ Ambient

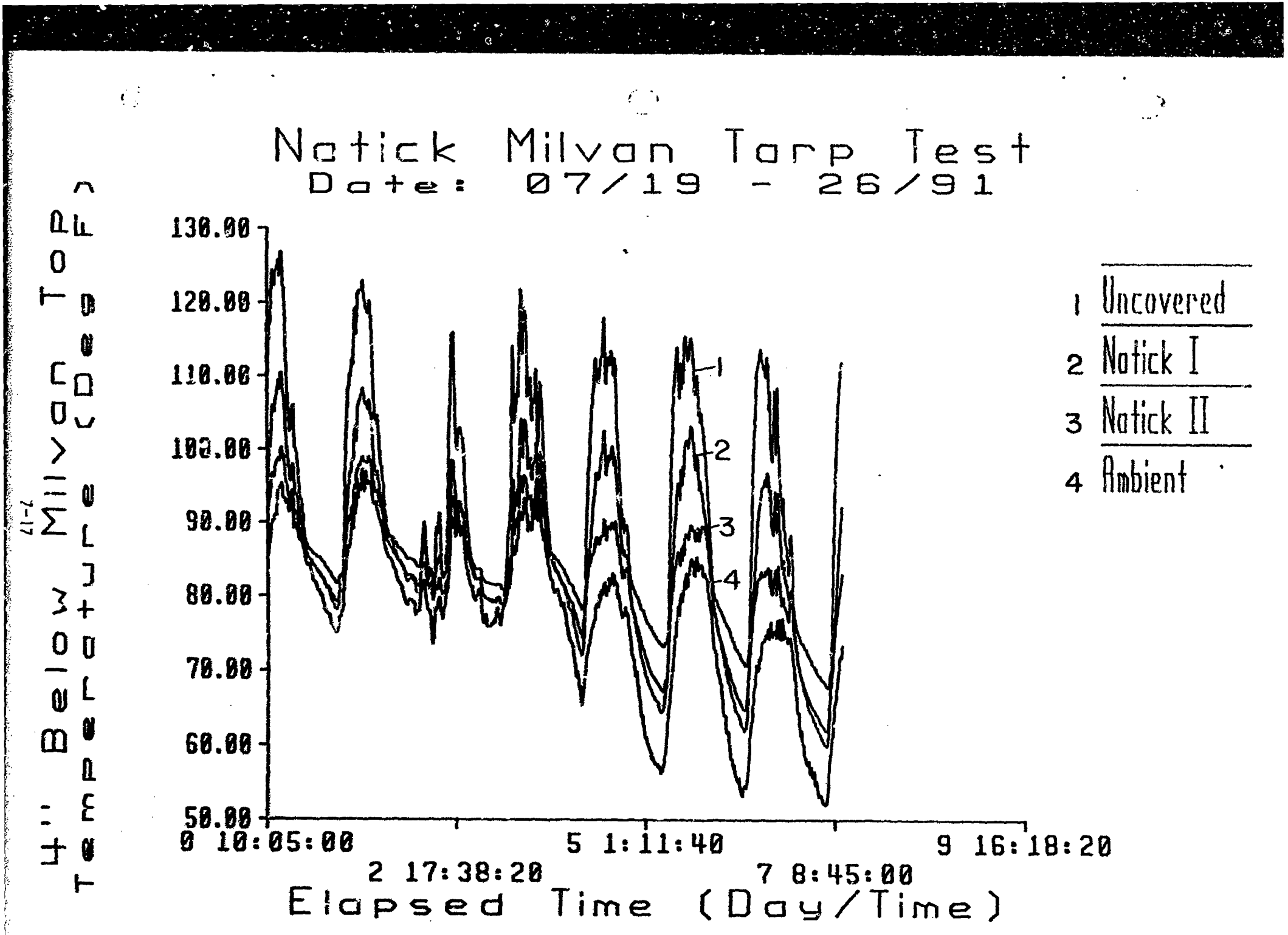

Natick Milvan Tarp Test
Date: 07/05 - 12/91
Top of Milvan Temperature (Deg F)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 13:15:00
2 20:48:20
5 4:21:40
7 11:55:00
9 19:28:20
Elapsed Time (Day/Time)

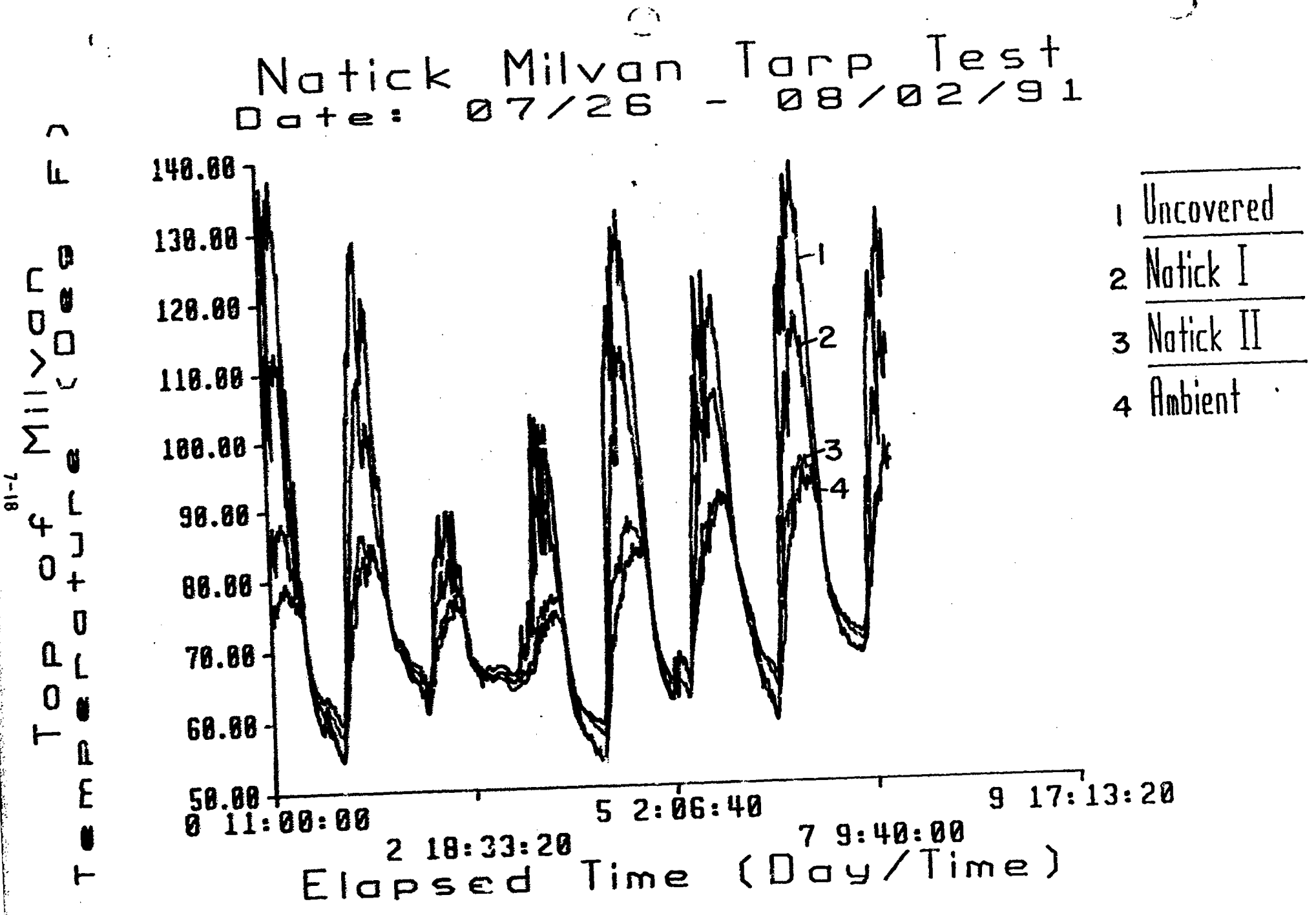

Natick Milvan Tarp Test
Date: 07/05 - 12/91
Temperature (Deg F)
Below Milvan Top
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 13:15:00
2 20:48:20
5 4:21:40
7 11:55:00
9 19:28:20
Elapsed Time (Day/Time)

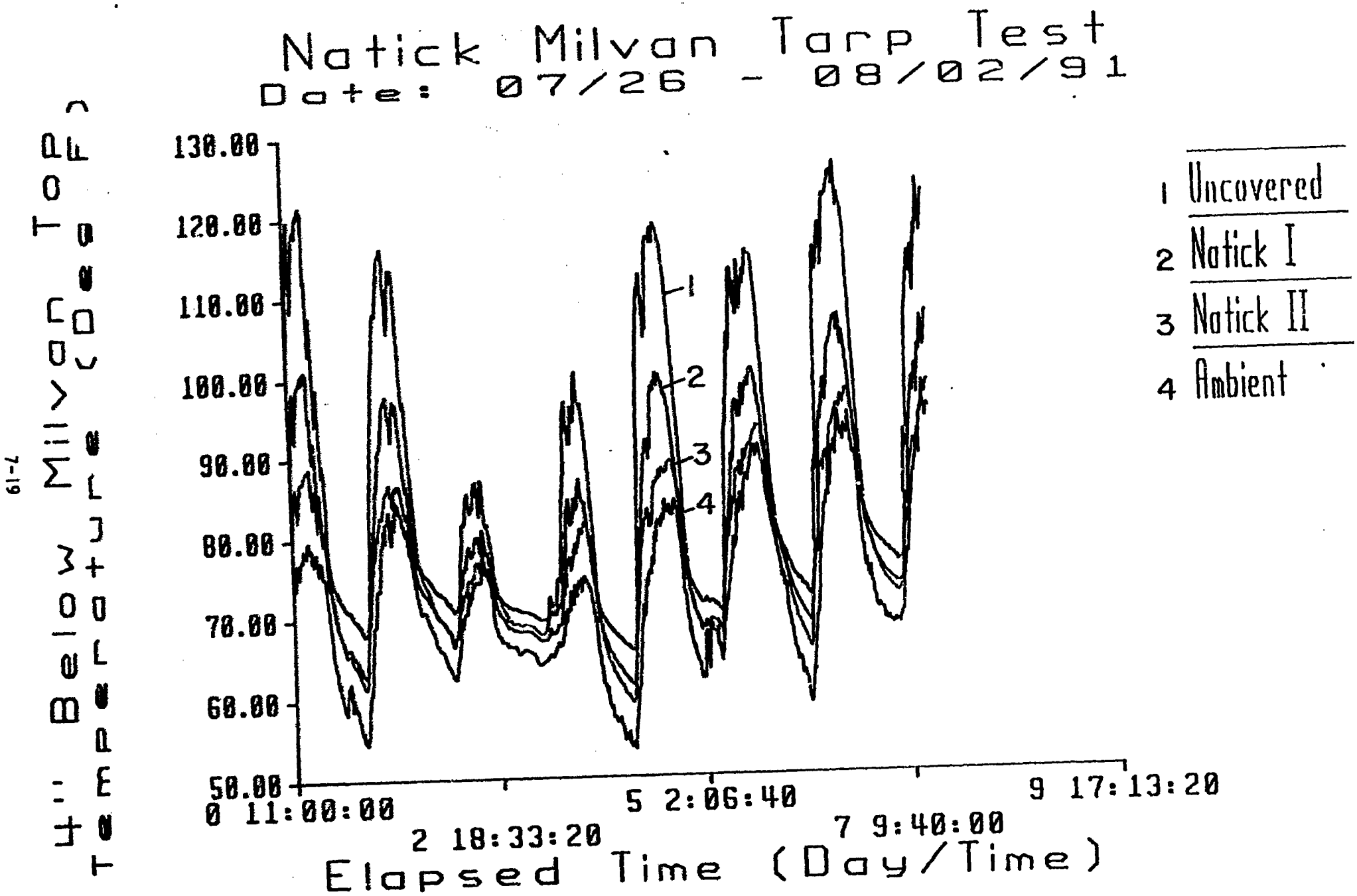

Natick Milvan Tarp Test
Date: 07/12 - 19/91
Top of Milvan (Deg F)
Temperature
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 15:10:00
2 22:43:20
5 6:16:40
7 13:50:00
Elapsed Time (Day/Time)

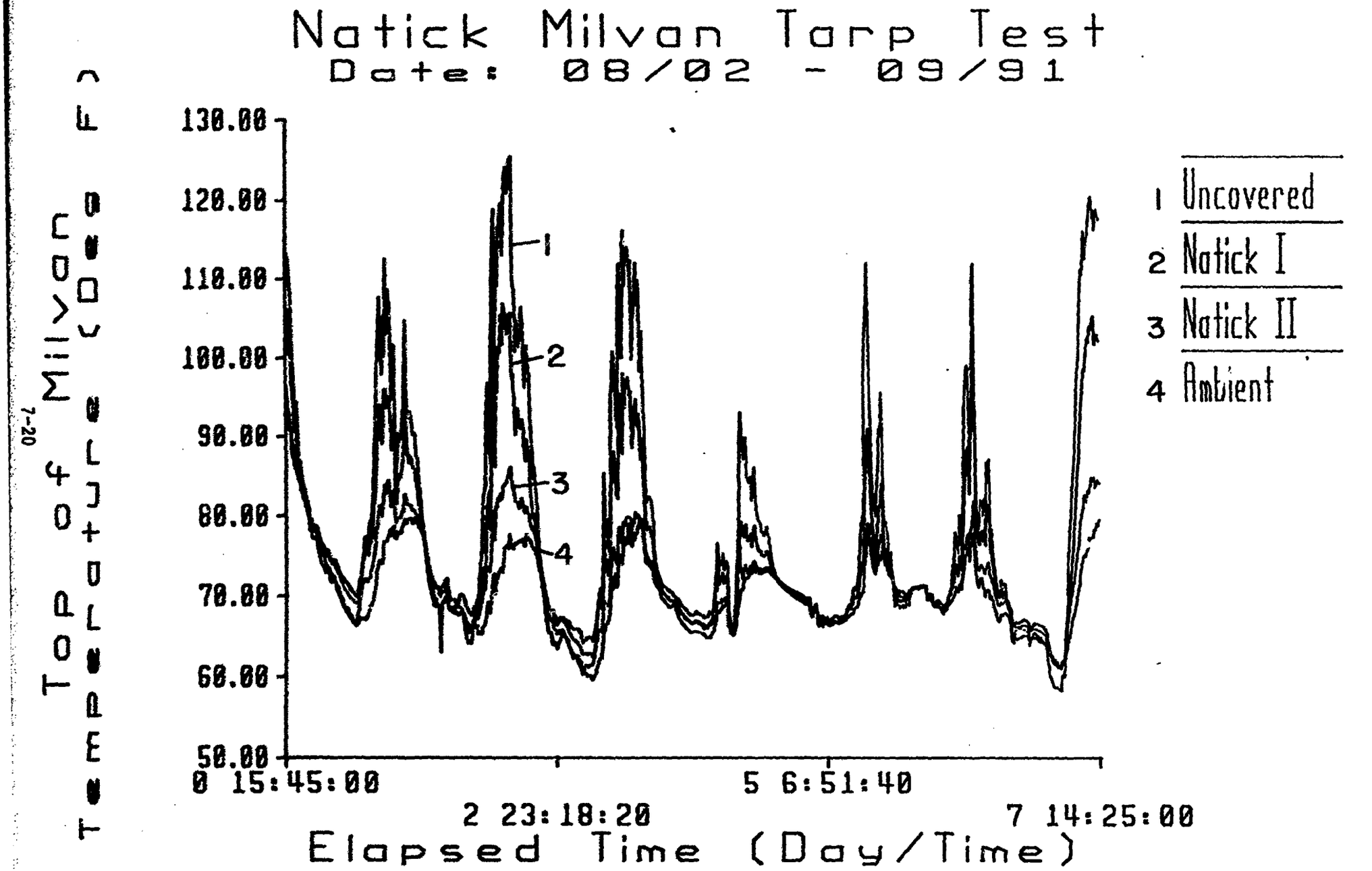

Natick Milvan Tarp Test
Date: 07/12 - 19/91
4: Below Milvan Tarp
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 15:10:00
2 22:43:20
5 6:16:40
7 13:50:00
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
1
2
3
4

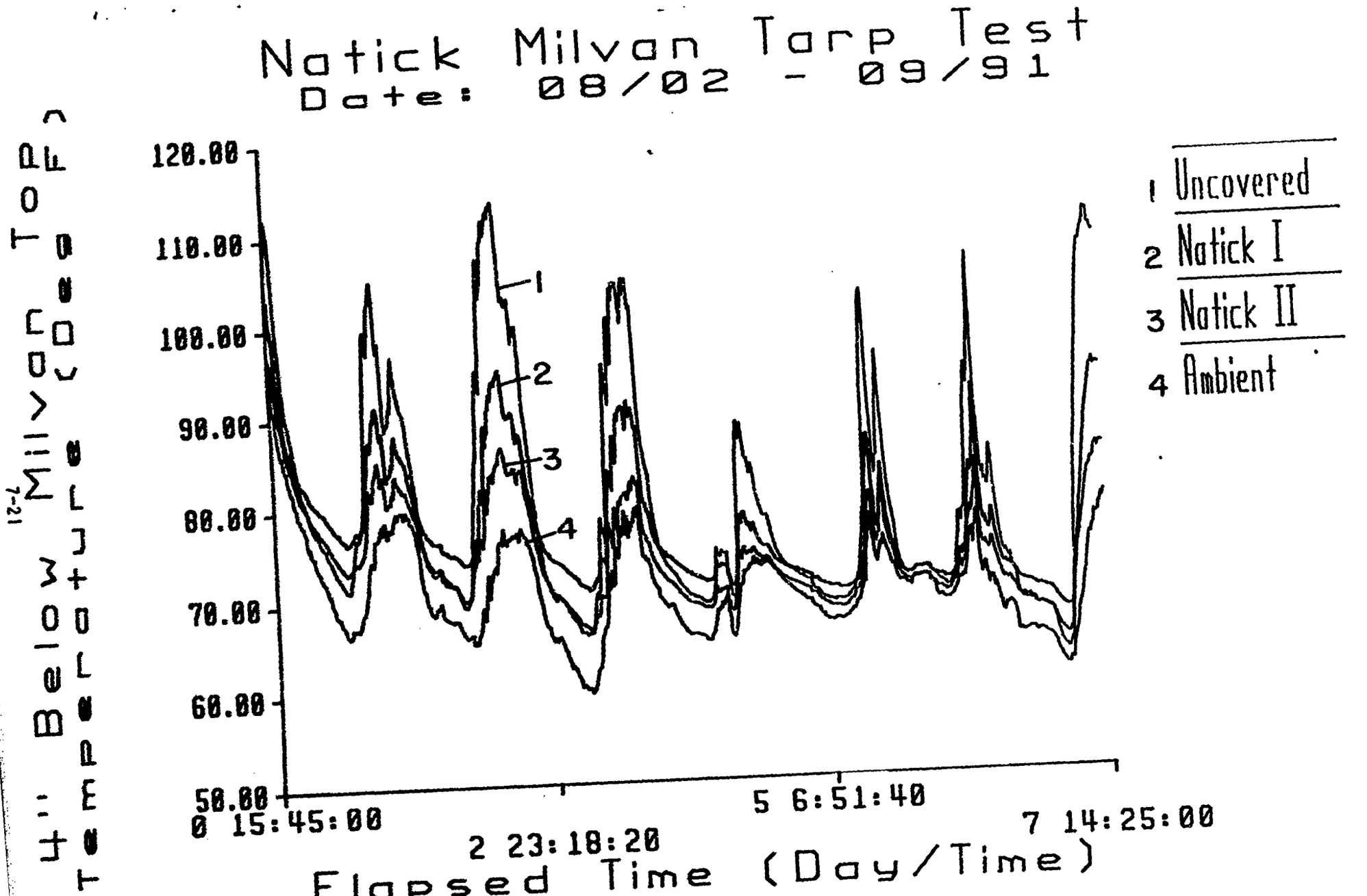

Natick Milvan Tarp Test
Date: 07/19 - 26/91
Top of Milvan Temperature (Deg F)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
0 10:05:00
2 17:38:20
5 1:11:40
7 8:45:00
9 16:18:20
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient

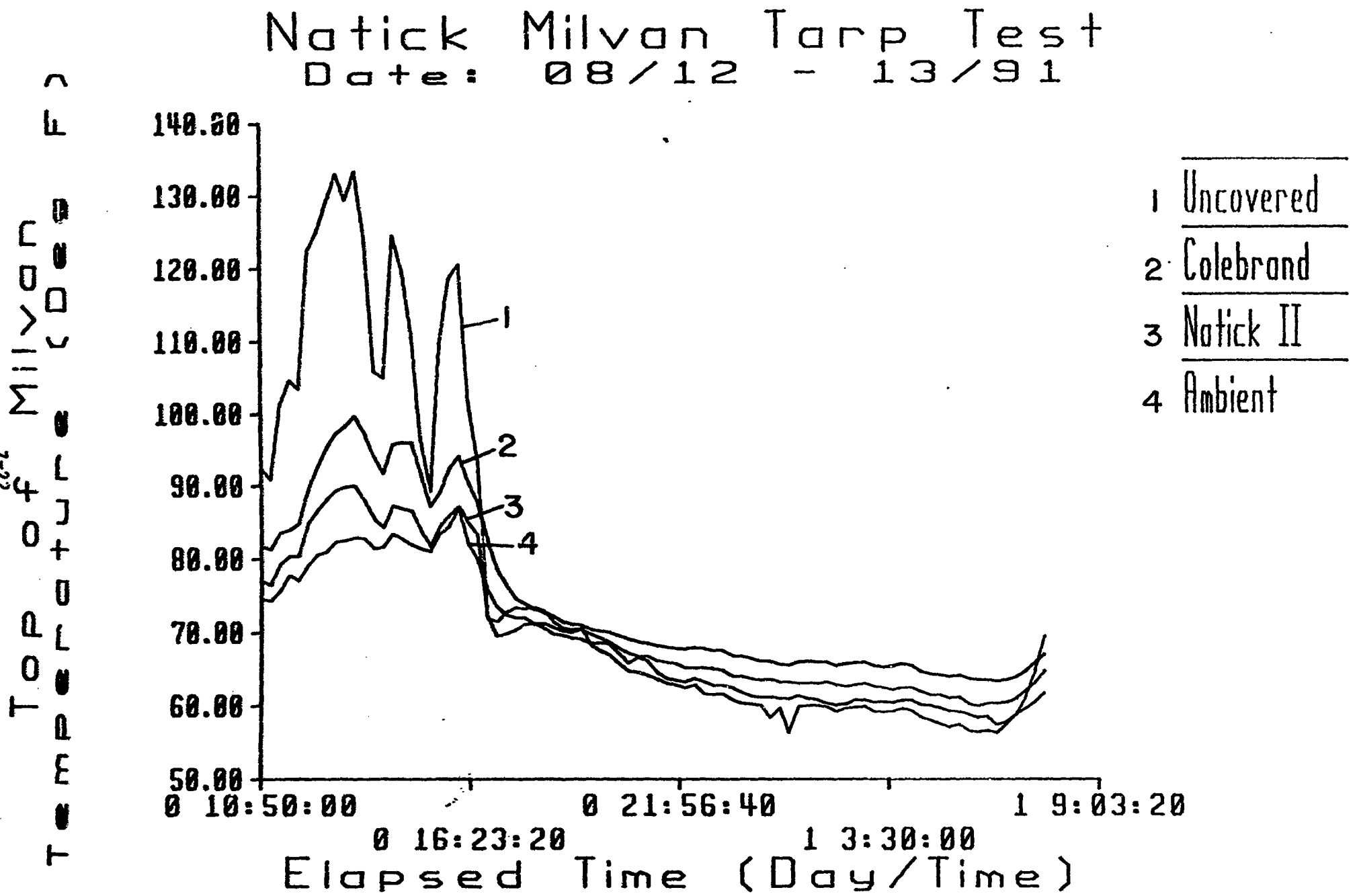

Notick Milvan Tarp Test
Date: 07/19 - 26/91
4" Below Milvan Top
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 10:05:00
2 17:38:20
5 1:11:40
7 8:45:00
9 16:18:20
Elapsed Time (Day/Time)
1 Uncovered
2 Notick I
3 Notick II
4 Ambient
1
2
3
4


Natick Milvan Tarp Test
Date: 07/26 - 08/02/91
Top of Milvan Temperature (Deg F)
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 11:00:00
2 18:33:20
5 2:06:40
7 9:40:00
9 17:13:20
Elapsed Time (Day/Time)
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
1
2
3
4


Natick Milvan Tarp Test
Date: 07/26 - 08/02/91
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 11:00:00
2 18:33:20
5 2:06:40
7 9:40:00
9 17:13:20
Elapsed Time (Day/Time)

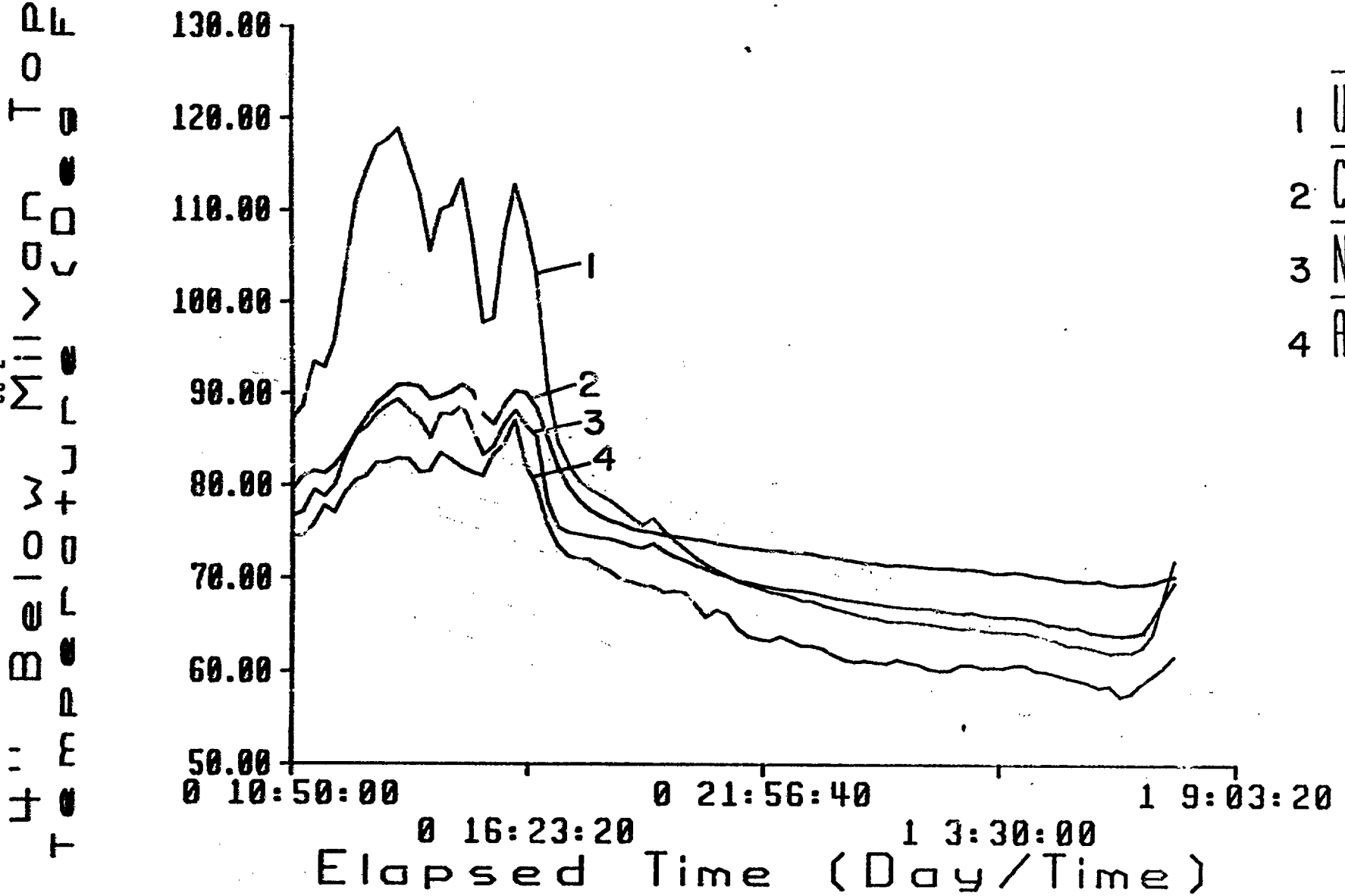

Natick Milvan Tarp Test
Date: 08/02 - 09/91
Top of Milvan Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 15:45:00
2 23:18:20
5 6:51:40
7 14:25:00
Elapsed Time (Day/Time)

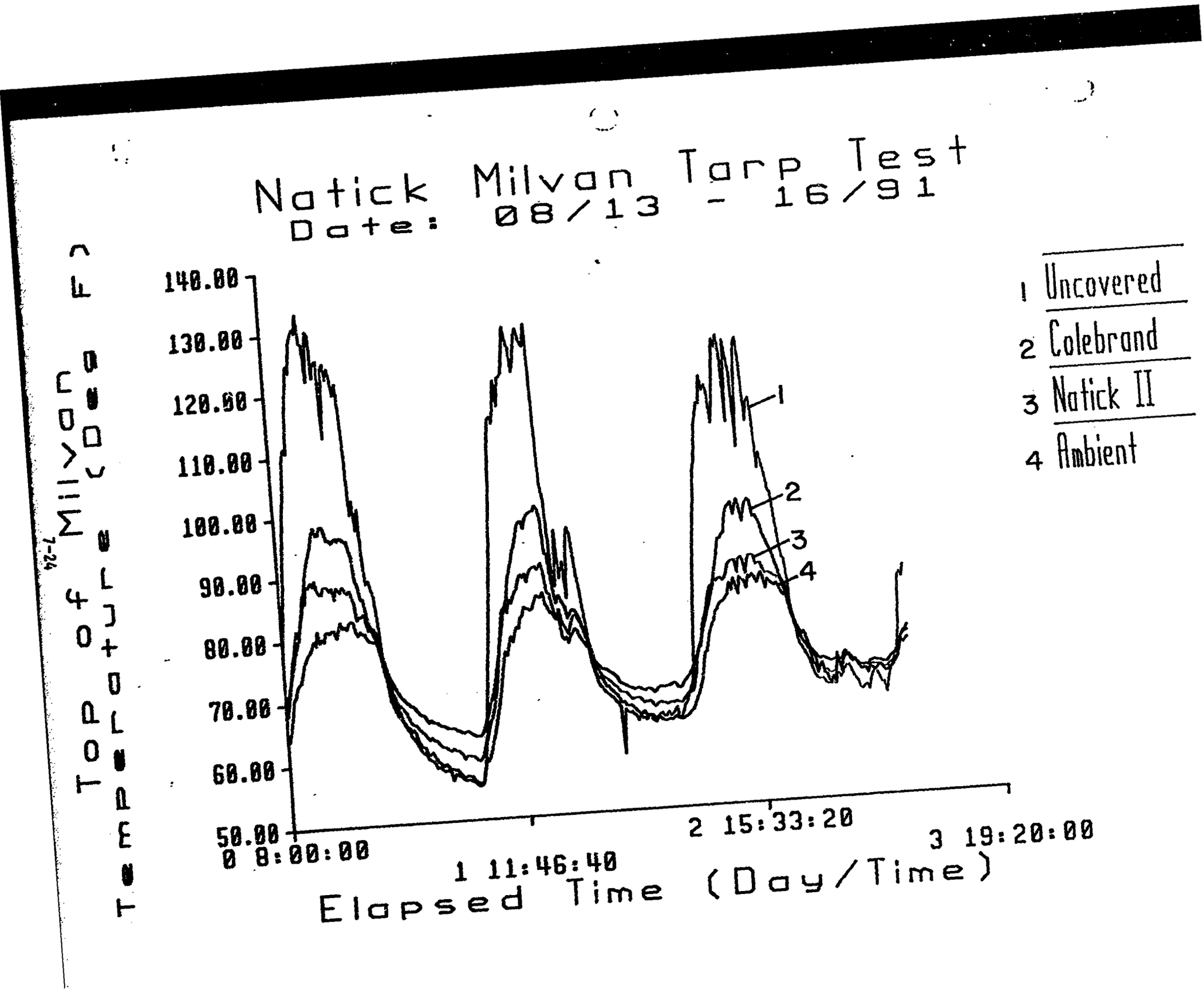

Natick Milvan Tarp Test
Date: 08/02 - 09/91
Temperature (°F)
4" Below Milvan Tarp
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Natick I
3 Natick II
4 Ambient
0 15:45:00
2 23:18:20
5 6:51:40
7 14:25:00
Elapsed Time (Day/Time)

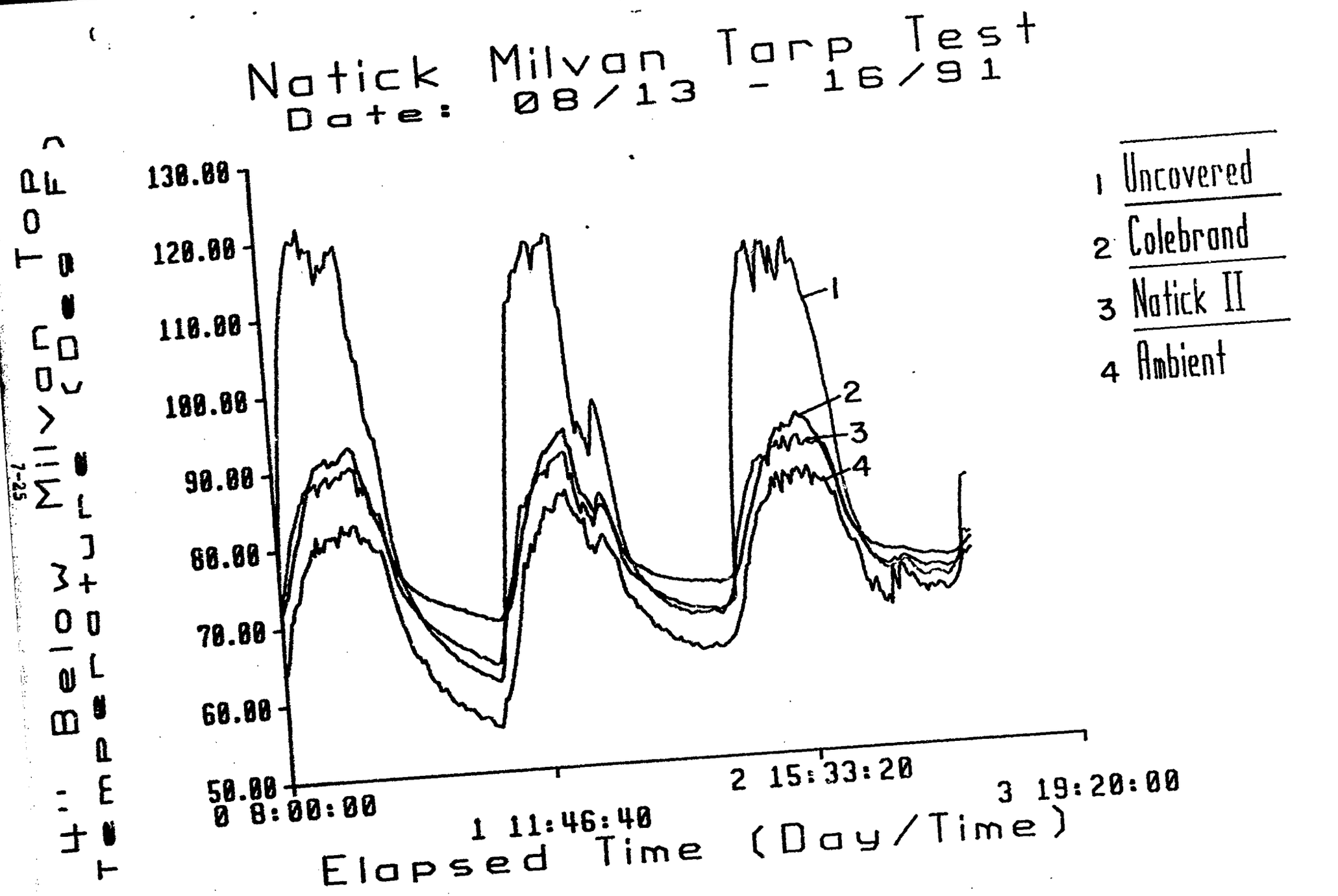

Natick Milvan Tarp Test
Date: 08/12 - 13/91
Top of Milvan Cover Temperature F
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1
2
3
4
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
0 10:50:00
0 16:23:20
0 21:56:40
1 3:30:00
1 9:03:20
Elapsed Time (Day/Time)

Natick Milvan Tarp Test

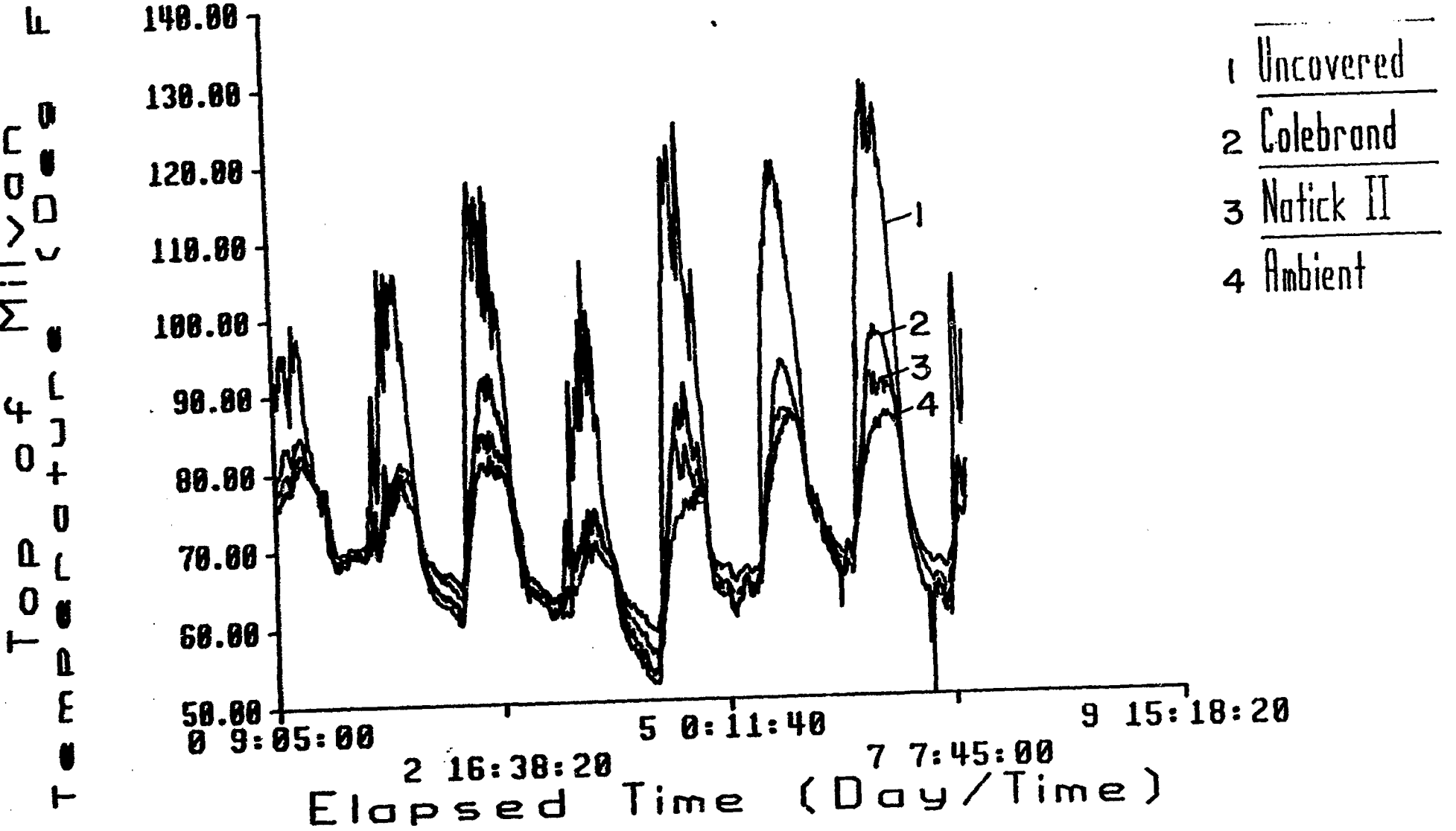
Date: 08/12 - 13/91




Natick Milvan Tarp Test
Date: 08/13 - 16/91
Top of Milvan (Deg F)
Temperature
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 8:00:00
1 11:46:40
2 15:33:20
3 19:20:00
Elapsed Time (Day/Time)
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
1
2
3
4
7-24

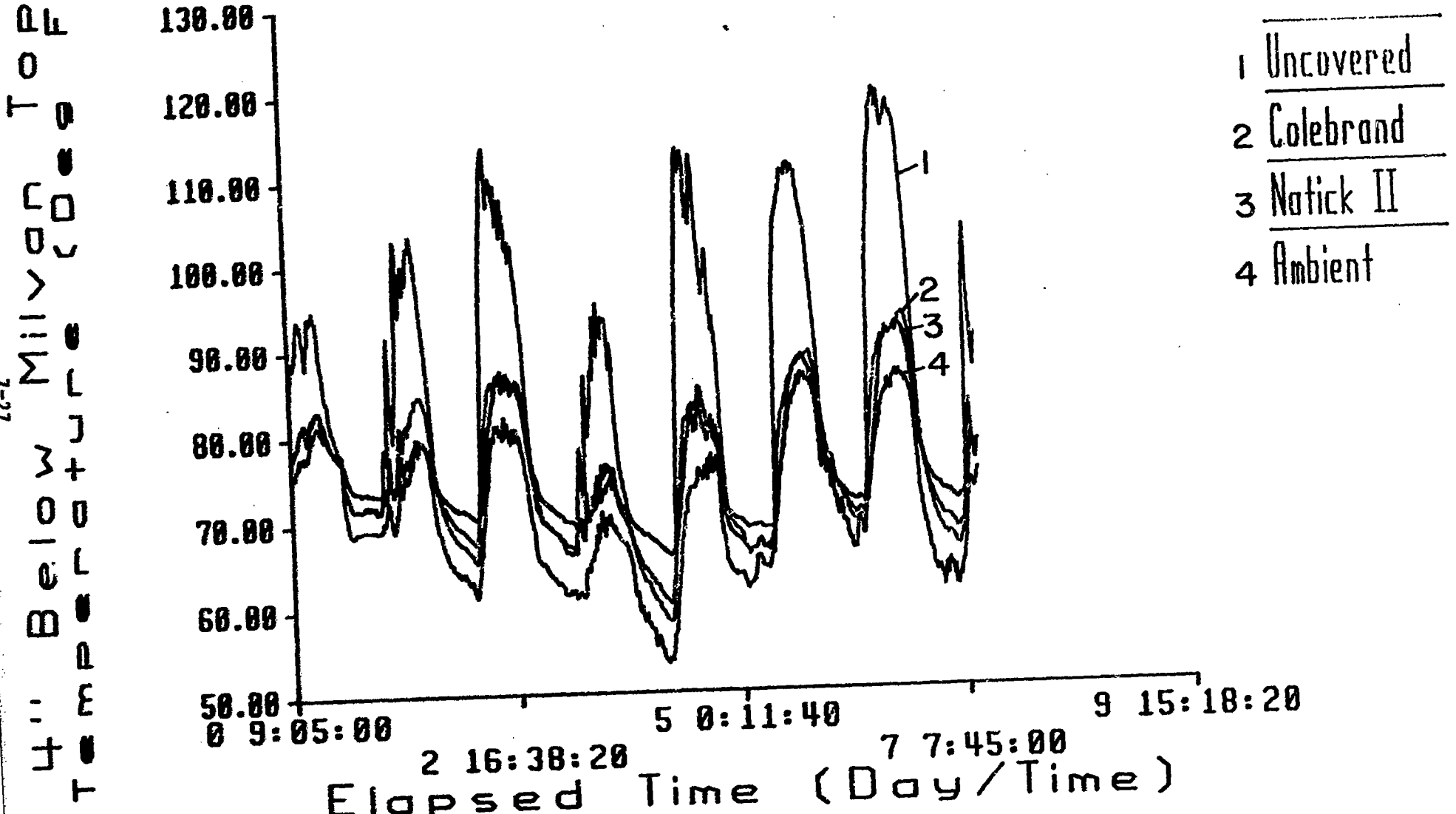

Natick Milvan Tarp Test
Date: 08/13 - 16/91
Temperature (Deg F) Below Milvan Tarp
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
0 8:00:00
1 11:46:40
2 15:33:20
3 19:20:00
Elapsed Time (Day/Time)
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
1
2
3
4
7-25

Natick Milvan Tarp Test
Date: 08/16 - 23/91



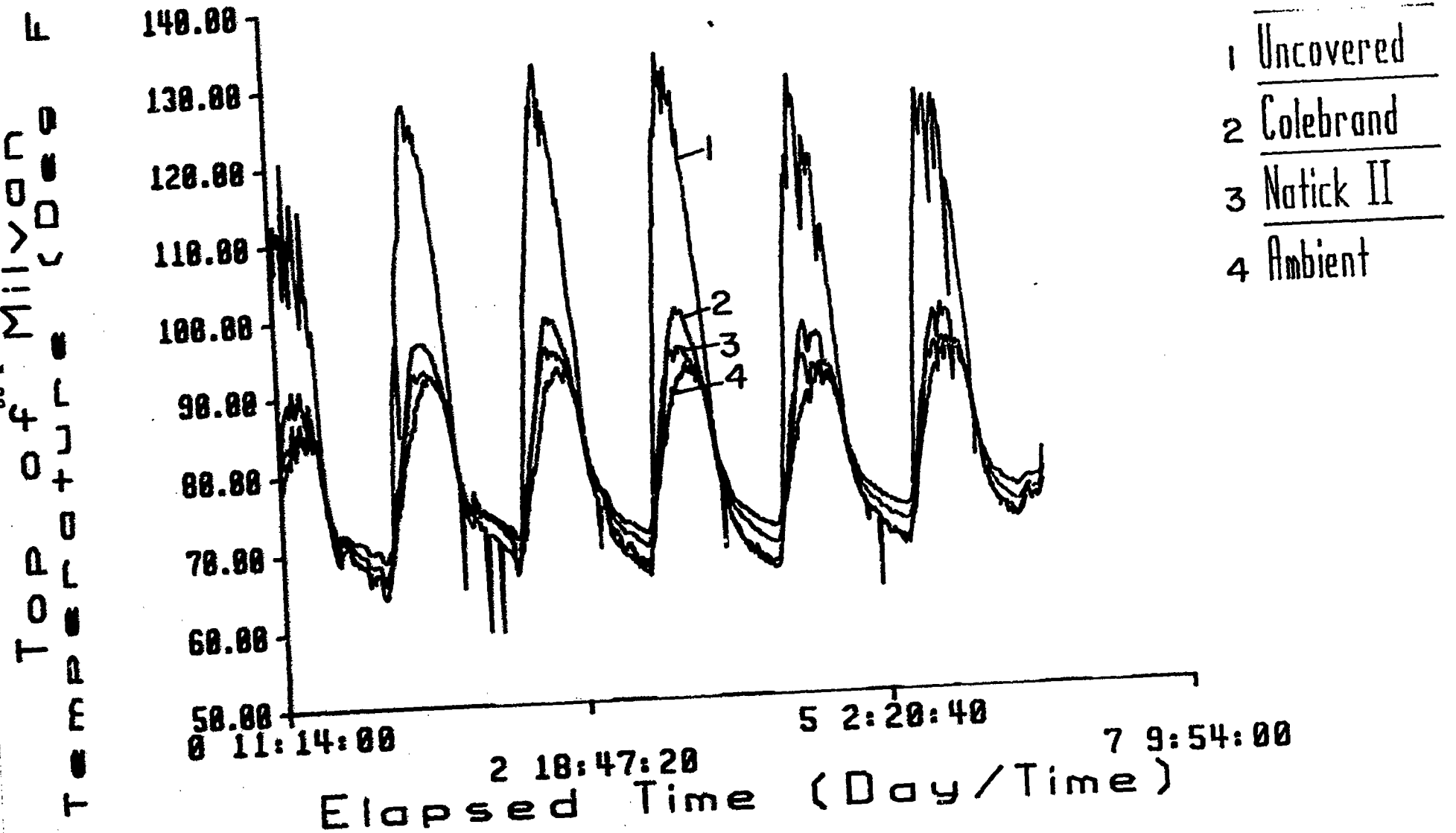
7-26

Natick Milvan Tarp Test
Date: 08/16 - 23/91



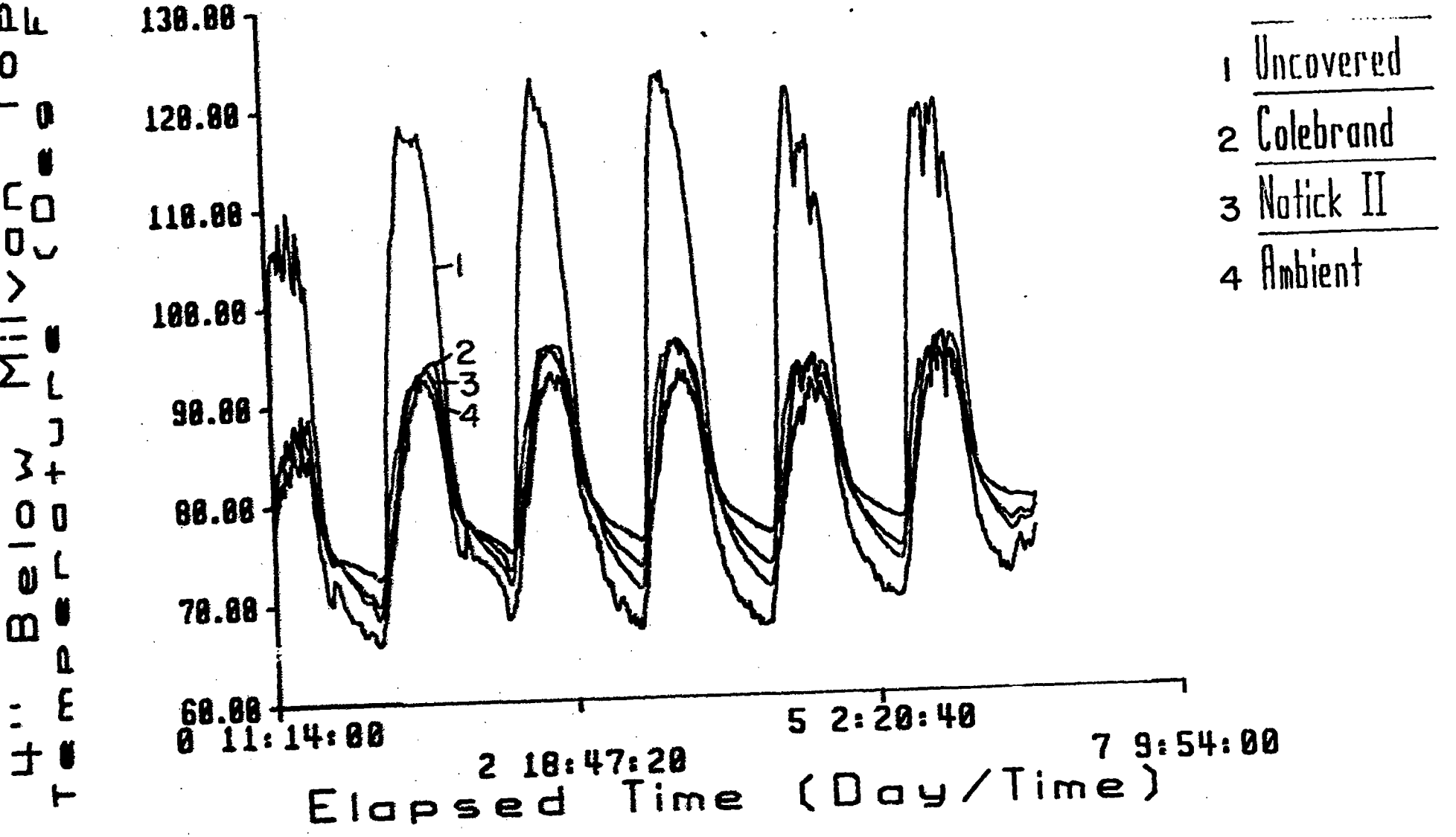
7-27

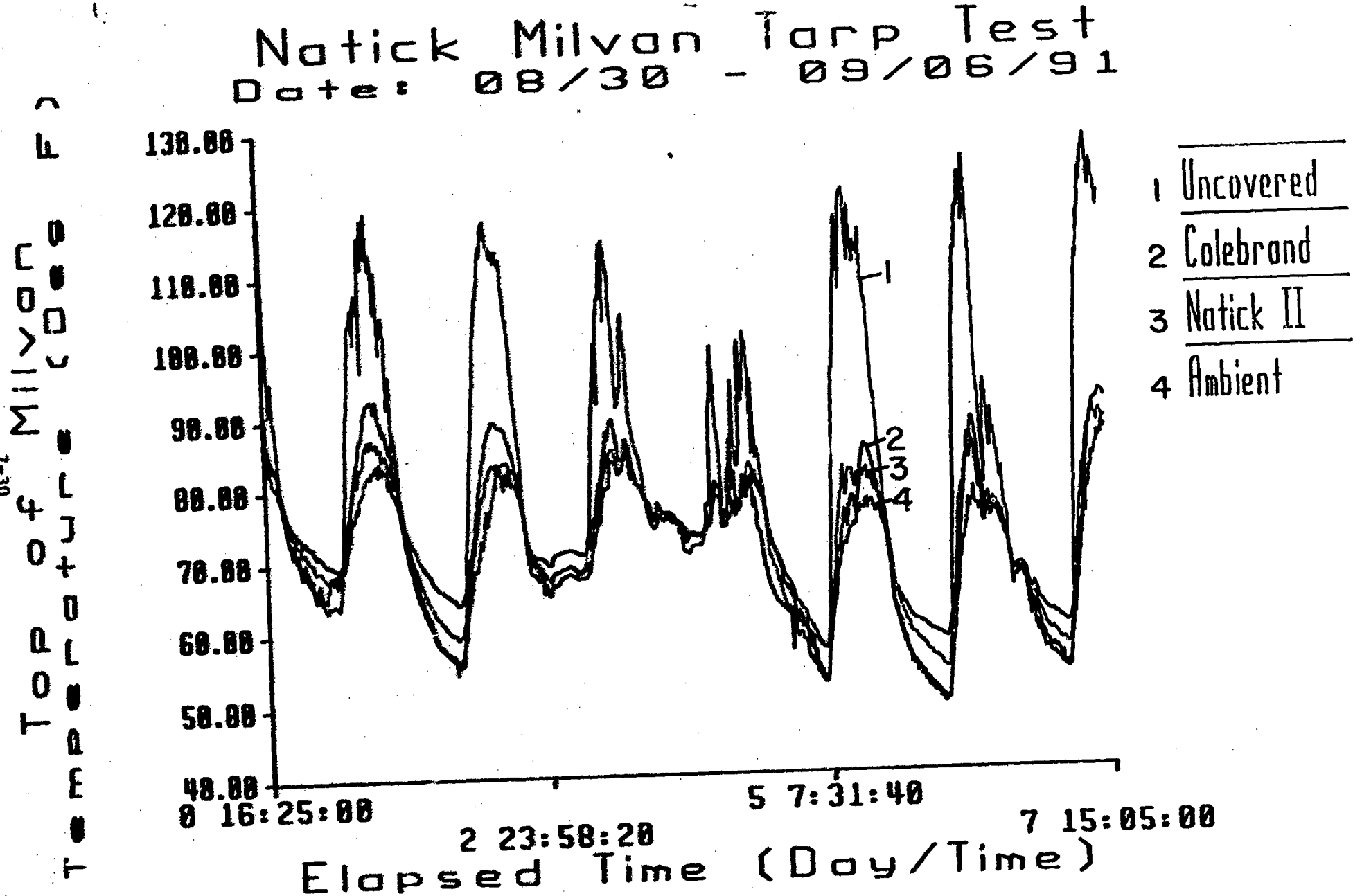
Natick Milvan Tarp Test
Date: 08/23 - 29/91

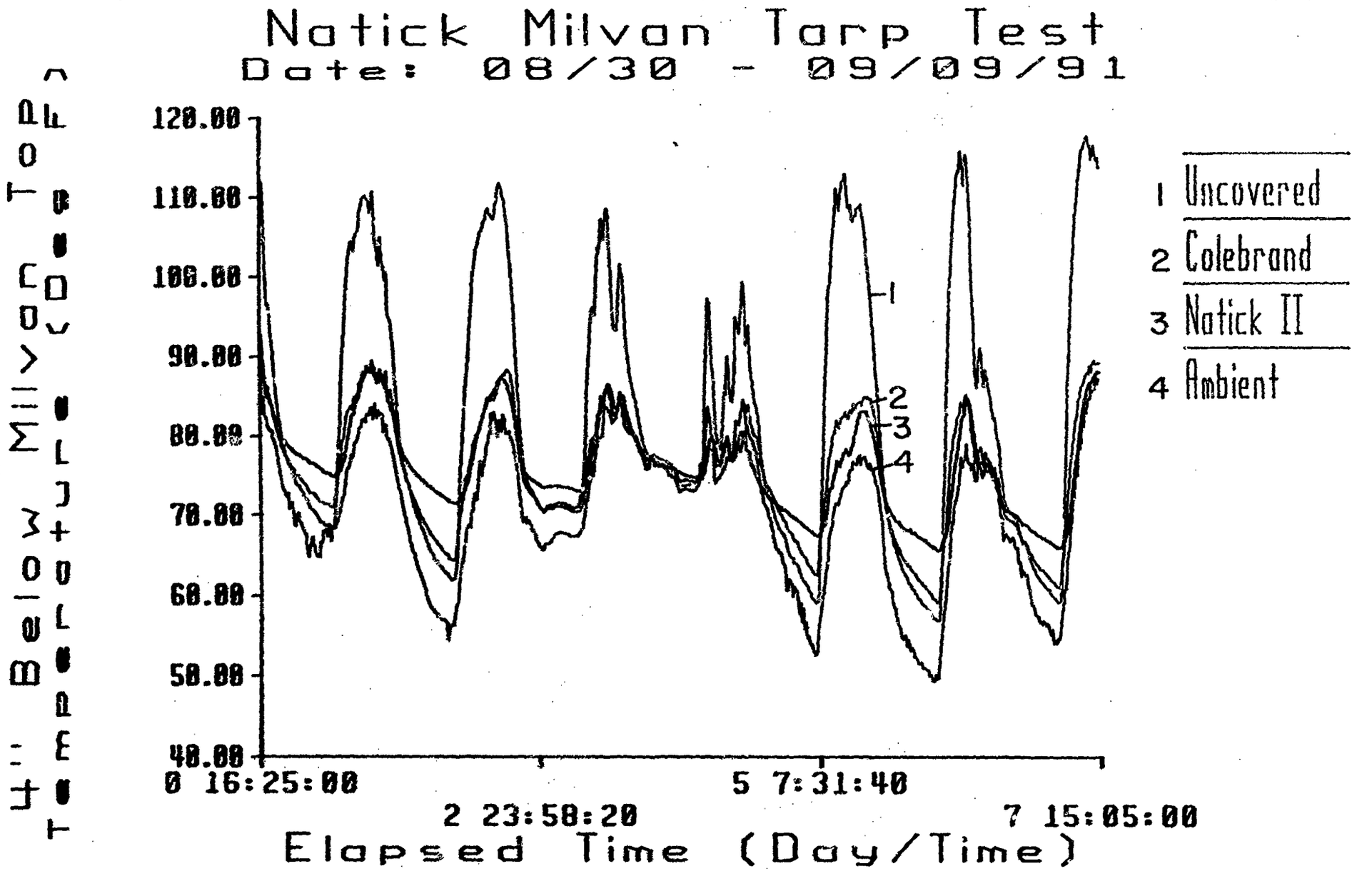


7-28

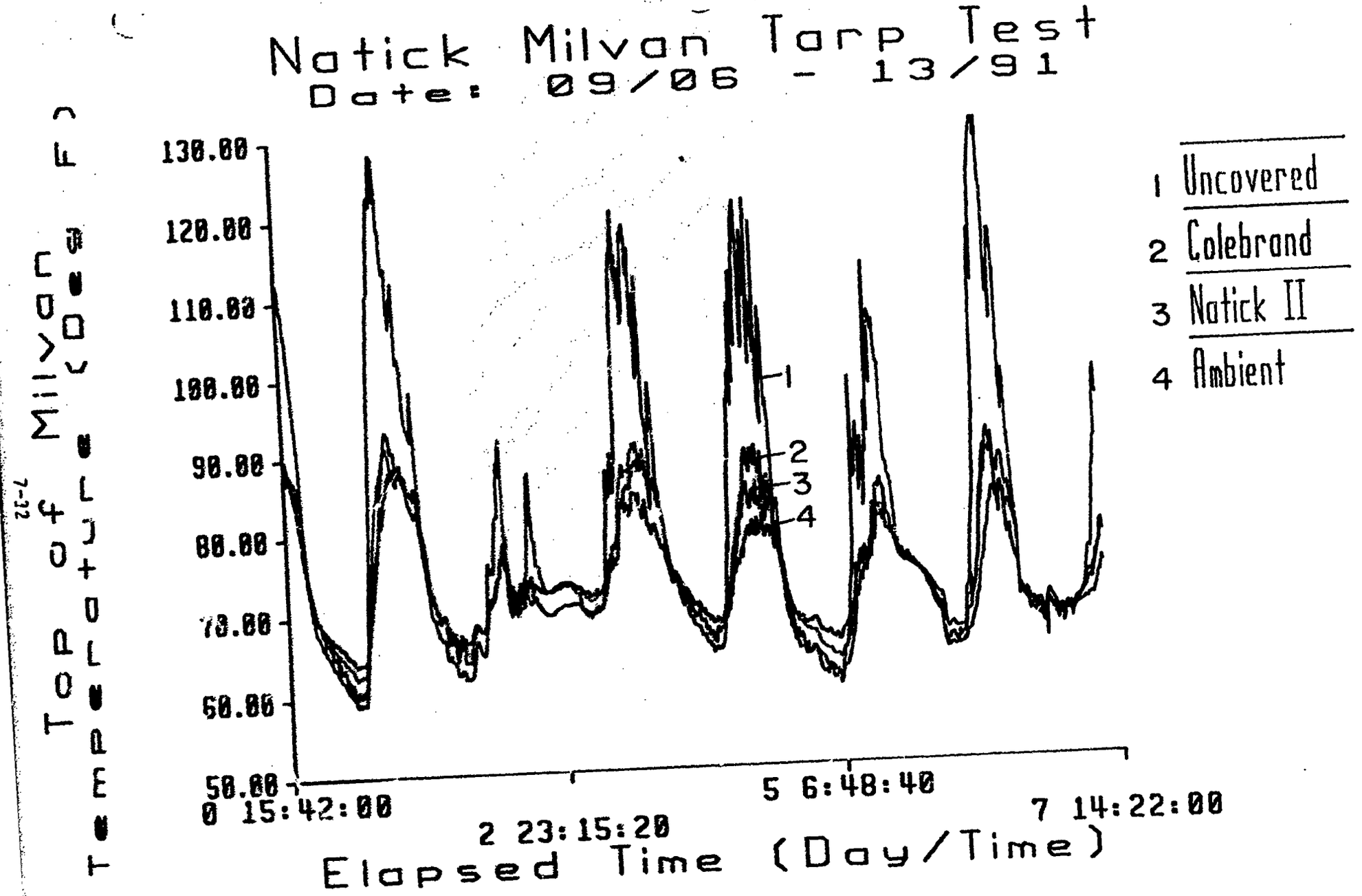
Natick Milvan Tarp Test
Date: 08/23 - 29/91

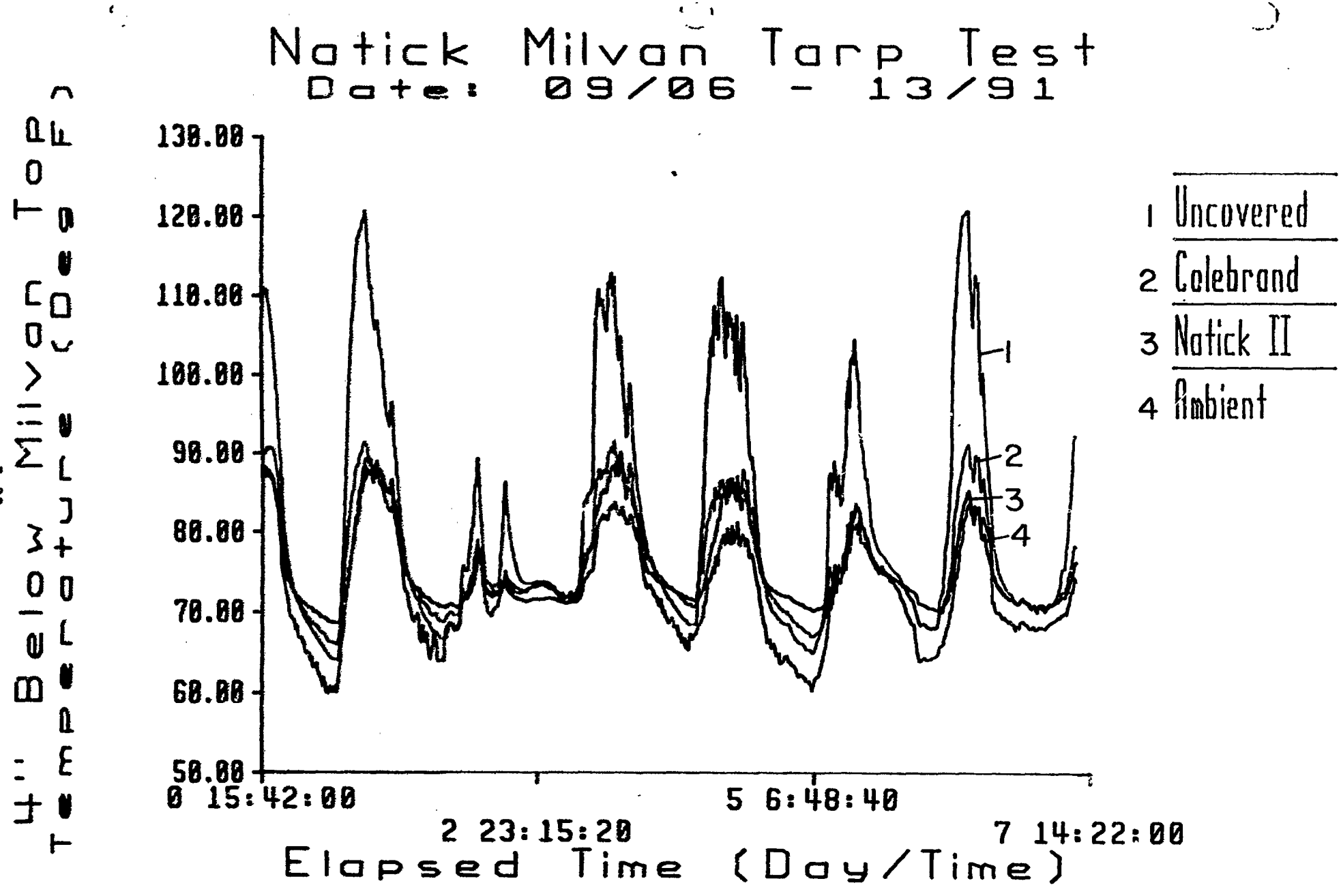



Natick Milvan Tarp Test
Date: 08/30 - 09/06/91
Top of Milvan Cover (F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0 16:25:00
2 23:58:20
5 7:31:40
7 15:05:00
Elapsed Time (Day/Time)
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
1
2
3
4


Natick Milvan Tarp Test
Date: 08/30 - 09/09/91
Temperature (Deg F)
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
0 16:25:00
2 23:58:20
5 7:31:40
7 15:05:00
Elapsed Time (Day/Time)
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
1
2
3
4

7-31


Natick Milvan Tarp Test
Date: 09/06 - 13/91
Top of Milvan (Deg F)
Temperature
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1 Uncovered
2 Colebrand
3 Natick II
4 Ambient
1
2
3
4
0 15:42:00
2 23:15:20
5 6:48:40
7 14:22:00
Elapsed Time (Day/Time)
7-22


Natick Milvan Tarp Test
Date: 09/06 - 13/91
4" Below Milvan Top
Temperature (Deg F)
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
1 Uncovered
2 Celebrand
3 Natick II
4 Ambient
1
2
3
4
0 15:42:00
2 23:15:20
5 6:48:40
7 14:22:00
Elapsed Time (Day/Time)

PART 8

APPENDIX

Specification for Colebrand Thermal Shield Cover for Standard ISO Container

INTRODUCTION

Standard ISO containers in an open and harsh marine environment will be exposed to very high levels of solar radiation throughout the daylight hours. The debilitating effects on the containers and contents - be they ammunition, electronic components, or perishable items - will have serious implications for operational effectiveness.

Colebrand has developed a Thermal Shield Cover for various aircraft, vehicles and other types of critical logistic stocks. These have been exhaustively tested by MOD(UK) research establishments and, in the US, by TACOM, NATC, and user representatives, both in test chambers and in field trials and evaluations.

CONCEPT

Colebrand's Thermal Shield Cover is carefully tailored to fit the object to be protected - aircraft, vehicle, storage container, etc. - so that if necessary, the cover can be left in place to provide constant thermal shielding. For an at-sea application, this arrangement precludes on board stowage problems. As a snug-fitting cover over five sides of a container, it also protects outer surfaces and covered equipment from the abrasive and corrosive effects of the marine environment. The fitting of camouflage nets does not effect the Thermal Shield Cover's performance.

DESIGN REQUIREMENTS

The Colebrand Thermal Shield Covers will be capable of being fitted by personnel wearing NBC clothing.

The outer materials used in Colebrand Thermal Shield Covers is a woven 100% polyacrylic, with a high tear resistance, good colorfastness, and high resistance against light and weather. The covers are solar reflective, durable, lightweight, occupy minimum volume, are oil and fuel resistant and flame retardant, have good anti-static properties, and can provide visual camouflage if necessary. Provision can be made for placement of container marking placard holders on the outer materials.

Pertinent aspects include:

Material width = 1/5th in.

Material weight = 330 c/m^2 or 9.66 oz./yd.^{2}

Material Tear Resistance: Warp = 150 daN/....
(DIN Stand 53354) Weft = 100 daN/....

Water Pressure Resistance: 100 mbar
(DIN Stand 53888)

Insulation Values: R = .1157 U = 8.643

The Colebrand Thermal Shield Covers will be fit snugly even in the strongest head or cross winds, with openings for corner fittings conforming to ISO 1161 (in effect as of 24 May 1991). Velcro openings permit container door access (as indicated in the photograph - Attachment A).

IMPLEMENTATION

Attachment of the Colebrand cover to the standard ISO container is by nylon cord laced through the eyelets at the edge of the shaped covers and those on the container. To prevent billowing and interference with sight-lines, tensioning straps are located along the sides. The cover will allow unimpeded access to the contents of the containers as it is designed to cover the side-opening doors of standard ISO-containers.

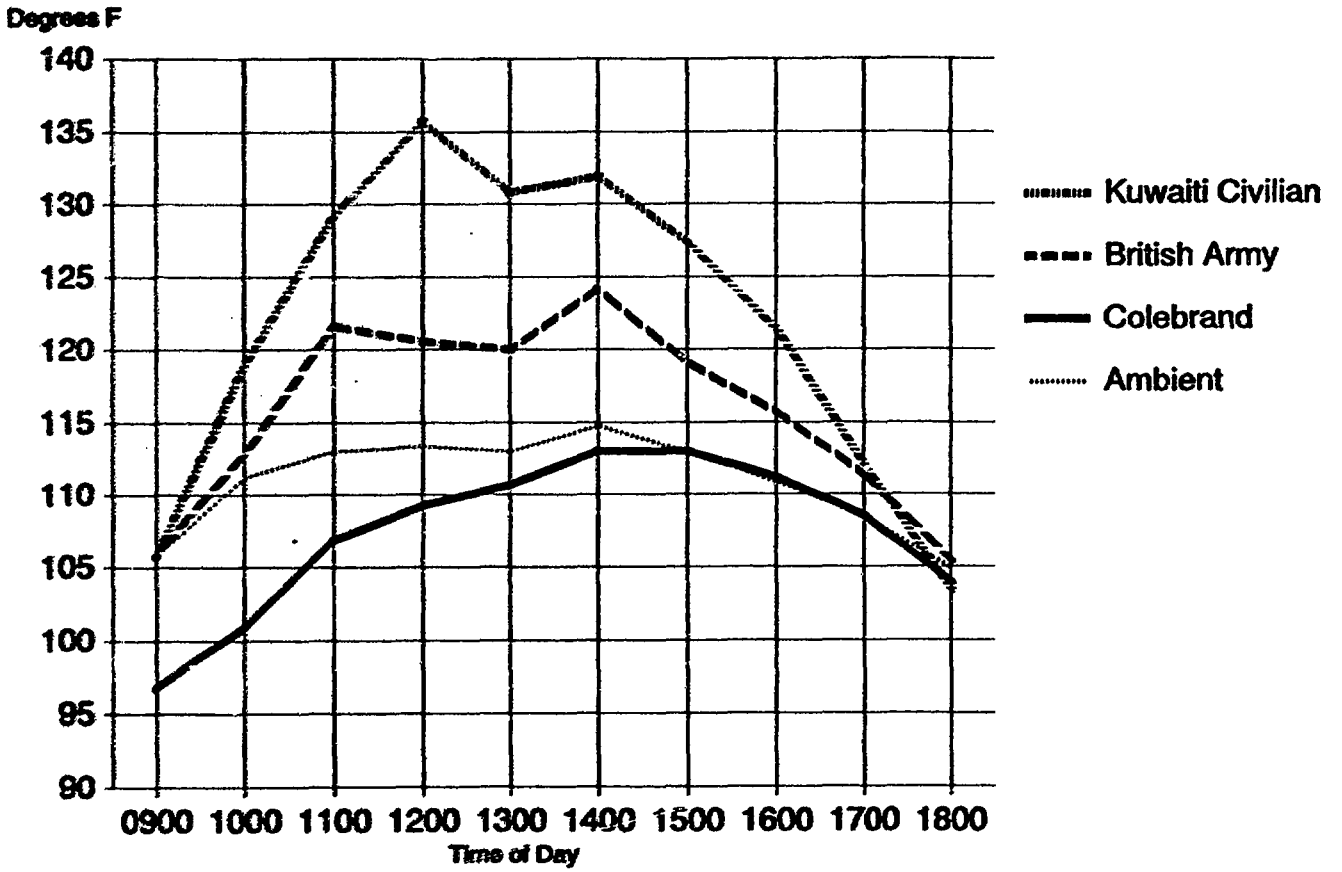
The Colebrand Thermal Shield Cover has been manufactured using Colebrand proprietary thermal material to give the highest possible thermal protection consistent with the need for minimum weight and volume.

The temperature reduction across the width of the cover is typically 70°F at 120°F ambient temperature. The thermal protection afforded storage containers is projected to enhance the overall shelf life of the container contents. Results from full scale tests in the MOD(UK) Climatic Laboratories are attached.

TEST RESULTS

Colebrand
Thermal Shield Covers

Tent Comparisons in Kuwait - JUL 91



THERMAL PROTECTIVE MATERIAL

APPLICATIONS FOR MILITARY EQUIPMENT

Colebrand

COLEBRAND THERMAL SHIELD COVERS

A Briefing

By: Richard L. Rumpf

THERMAL PROTECTIVE MATERIAL

APPLICATIONS FOR MILITARY EQUIPMENT

Colebrand

COLEBRAND THERMAL SHIELD COVERS

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By: Richard L. Rumpf

THE PROBLEM

Colebrand
Thermal Shield Covers

Intense Solar Heating Causes:

- Warping/Bubbling of A/C Canopies/Windscreens
- Fuels to Reach Flash Point Conditions
- Ammunition Ballistics to Deteriorate and Shelf Life to Shorten
- Crew Conditions to Become Unbearable
- Materials to Distort, Soften, and Even Run
- Maintenance Crews to Be Severely Limited in Maintenance Time Due to Excessively Hot Metal Parts and Heat Exhaustion
- Excessive Loads on Air Conditioning Systems

DESERT ENVIRONMENT

Colebrand
Thermal Shield Covers

Climatic Conditions

	NOVEMBER - MARCH	APRIL - OCTOBER
Maximum Temperature (°F)	95	116
Avg. Daily Max. Temp. (°F)	76	101
Avg. No. Days/Mo. w/Max Temp. > 100°F	< .5	20
Avg. Monthly Precip. (in.)	.6	< .03
Avg. No. Days w/Fog	1.8	< 1
Rel. Humidity at 0300 (%)	77	58
Rel. Humidity at 1200 (%)	47	26
Mean Monthly Wind Speed (KTS)	10.2	9.2

1990 Data From Bahrain, King Abdul Azia, Dhahran

DESERT ENVIRONMENT, contd.

Colebrand
Thermal Shield Covers

Climatic Conditions, contd.

SPECIAL TEMPERATURE NOTES	JUN	JUL	AUG	SEP
# Days w/Max Temp > 110°F	4	6	3	1
# Days w/Max Temp > 100°F	28	30	31	24
# Hrs/Day w/Temp > 100°F			10	> 4
# Days w/ > 4 hrs. Blowing Sand (of Hi Temp Days)			1	5

	SEPTEMBER	OCTOBER
Avg./Max Black Globe Temp. (°F - 0900-1500)	113 / 126	108 / 122

1990 Data From Bahrain, King Abdul Aziz, Dhahran

TEMPERATURE PROFILE

Colebrand
Thermal Shield Coyers

SOUTHWEST ASIA

MONTHS	SAUDI ARABIA		IRAQ		KUWAIT	
	LOW(°F)	HIGH(°F)	LOW(°F)	HIGH(°F)	LOW(°F)	HIGH(°F)
JANUARY	28	50	28	60	38	70
FEBRUARY	32	52	30	65	42	72
MARCH	45	80	50	70	55	75
APRIL	60	95	65	95	60	80
MAY	65	100	65	105	65	100
JUNE	40	125	45	128	50	130
JULY	45	128	50	130	55	135
AUGUST	50	130	55	120	60	135
SEPTEMBER	50	120	50	120	58	130
OCTOBER	60	85	62	82	65	85
NOVEMBER	52	70	50	70	50	80
DECEMBER	32	58	32	65	42	75

SOURCE: MERIT STUDENT ENCYCLOPEDIA

TEMPERATURE LIMITS

Colebrand
Thermal Shield Covers

105mm Tank Ammunition

ITEM	FIRING		STORAGE	
	LOWER LIMIT (°F)	UPPER LIMIT (°F)	LOWER LIMIT (°F)	UPPER LIMIT (°F)
M392 & A2	-40	125	-80	160
M393A1 & A2	-40	125	-80	160
M416	-40	125	-80	160
M456, E1 & A1	-40	140	-65	145
M456A2	-40	125	-65	145
M467	-40	125	-80	160
M490 & A1	-40	125	-80	160
M494	-40	125	-65	145
M724 & A1	-40	125	-80	160
M728	-60	125	-65	145
M735	-25	125	-65	160
M774	-35	125	-70	160
M833	-35	125	-50	145
M900E1	-20	120	-35	145

TEMPERATURE LIMITS

Colebrand
Thermal Shield Covers

120mm Tank Ammunition

ITEM	FIRING		STORAGE	
	LOWER LIMIT (°F)	UPPER LIMIT (°F)	LOWER LIMIT (°F)	UPPER LIMIT (°F)
M829	-50	145	-50	145
M829A1	-25	120	-50	145
M830	-50	145	-50	145
M831	-50	145	-50	145
M865	-50	145	-50	145

THERMAL SHIELD MATERIAL

Colebrand
Thermal Shield Covers

✓ Is a Thin Multilayer Cloth Blanket Comprising:
- An Outer Layer of Very Strong Fabric Treated to be Fire Retardant, Waterproof, Fuel and Oil Resistant
- Multiple Inner Layers of Reflective Material and UV Absorbers
- Bottom Layer Artificial Silk with Sand Trap as Needed

✓ Works Very Effectively in Reflecting and Absorbing the High Thermal Energy of the Sun

✓ Has Some IR Signature Reduction Capability

✓ Has Insulating Value in Cold Weather Conditions

✓ Comes in Any Color, Weighs 1 kg/m^2

✓ Can be Form Fitted or Left Loose & Tent-Like

THERMAL SHIELD MATERIAL

Colebrand
Thermal Shield Covers

USERS / EVALUATORS

- **RAF/ITALIAN AF -- All Tornados in SWA**
- **RN -- Sea King/Puma/Chinook Covers Measured**
- **USAF -- F-15 Proto Tested at Nellis (OCT 90)**
- **CANADA -- CF-18 Demo Requested**
- **USN / USMC:**
  Prototypes for AH-1W, AV-8B, F/A-18
  Excellent Thermal Results
- **BRITISH ARMY:**
  Challenger MBT/Variants, Satellite Comms, Ptarmigan CVs,
  Rapier SAM, Special EW Vehicle
- **US ARMY:**
  Prototypes for M1, M2, M113 APV, S250 Shelters
  Tested at TACOM -- Excellent Results

APPLICATIONS

Colebrand
Thermal Shield Covers

FOR COLEBRAND THERMAL SHIELD COVERS

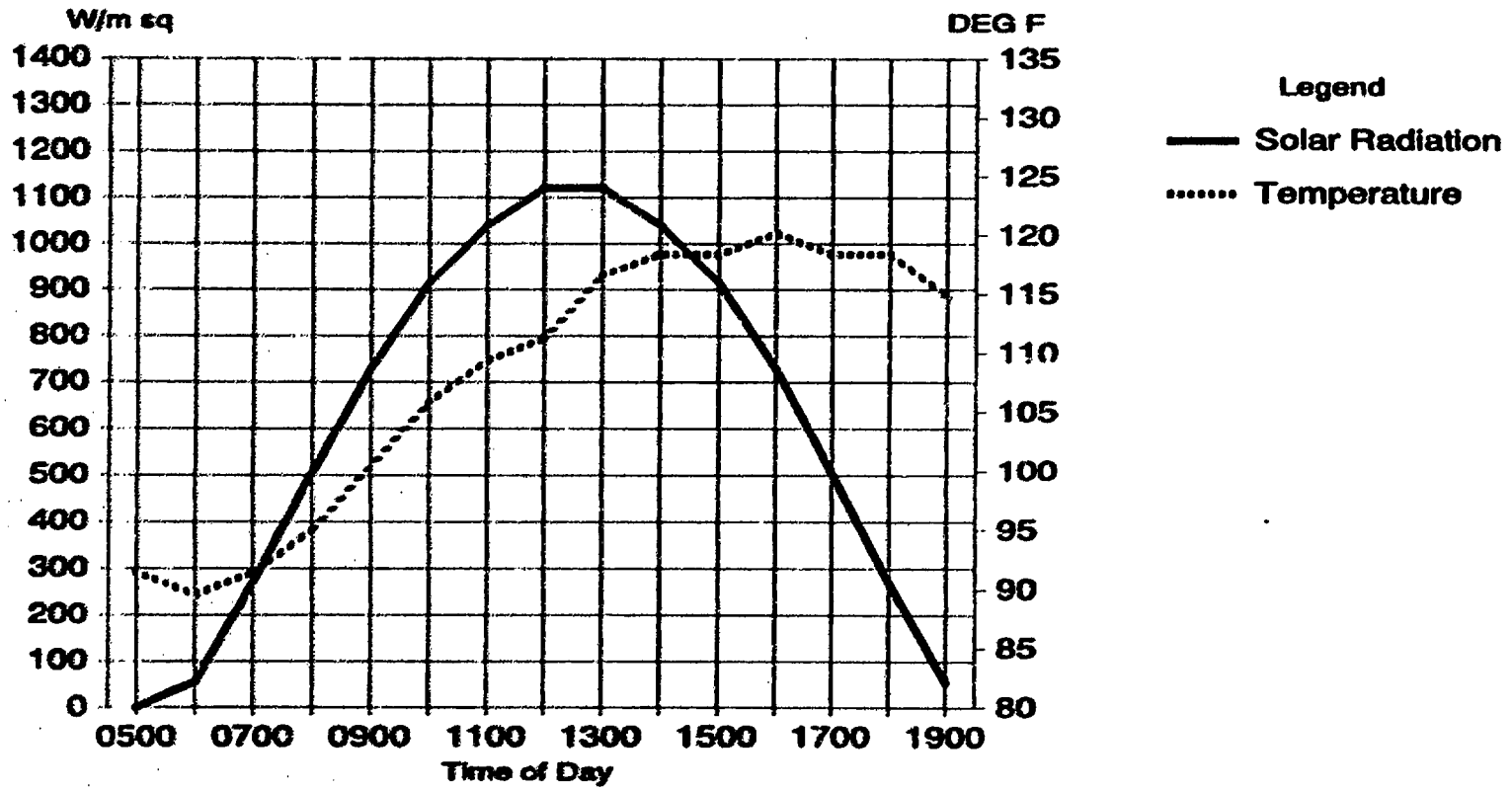
- Fuel and Water Supply Trucks
- Fuel and Water Supply Tanks & Bladders
- Aircraft Canopies (Fixed & Rotary Wing)
- Armored Vehicles: Main Battle Tanks, APCs, LAVs, etc.
- Command & Control Vehicles
- Satellite Communications Vans
- Guided Missile Control and Fire Units
- Shelters for Maintenance/Repairs
- Ammunition Storage Containers
- Helmet Covers
- Tenting for Hospitals, Food Storage, Field Housing, Ordnance Storage Bunkers, etc.
- Desalinization Units
- Diving Bell and Air Storage Units

TEST DATA

TEMPERATURE / SOLAR LOADING

Colebrand
Thermal Shield Covers

Temperature / Solar Loading

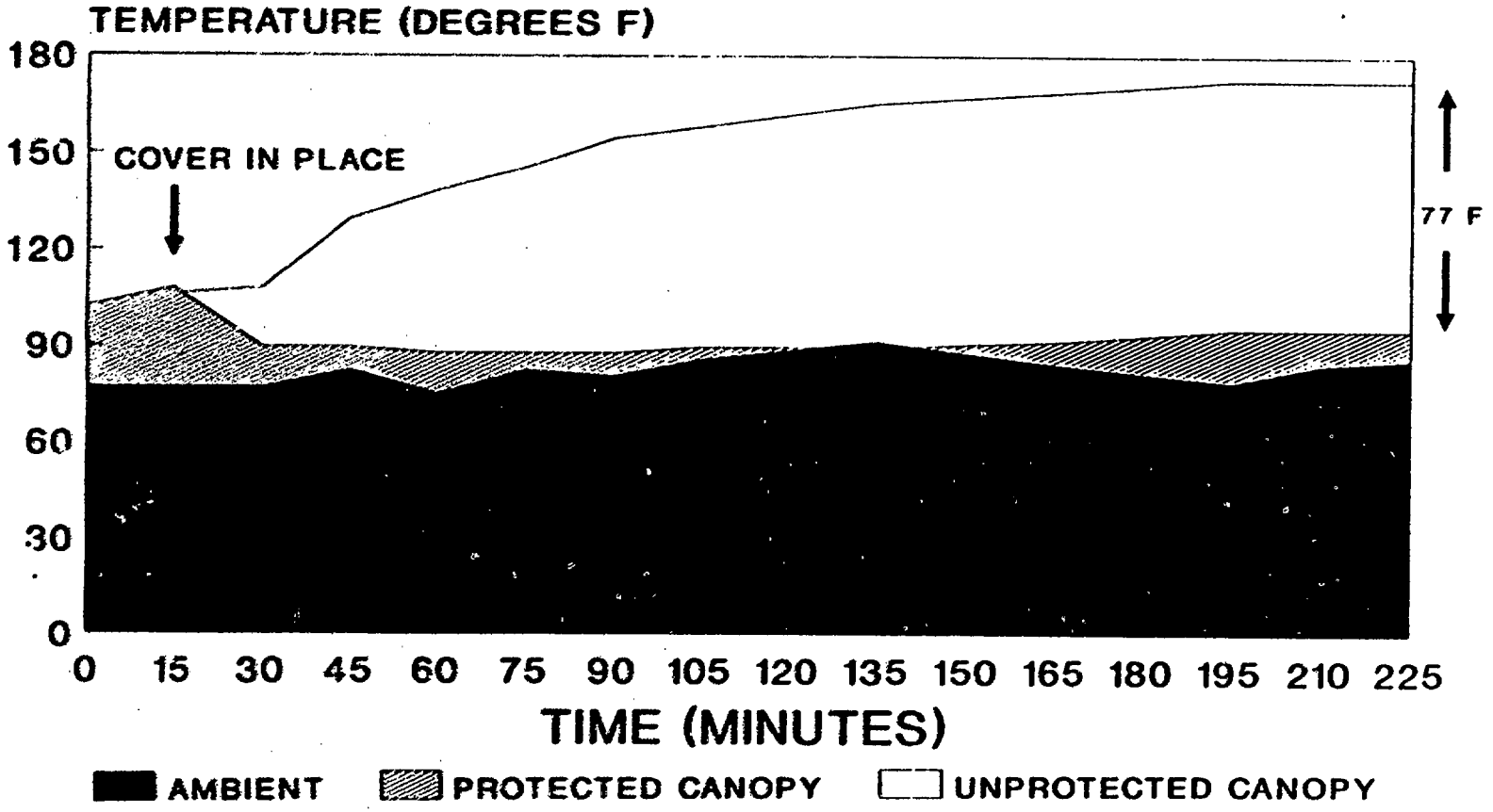


RARDE CHERTSEY DATA (DEF STAN 00 - 1/2) CONDITION A1 (HOT, DRY)

TEST RESULTS

Colebrand
Thermal Shield Covers

F-15 Trial at Nellis AFB -- October 90



AMBIENT TEMPERATURE READINGS BEGAN AT +30 MIN

TEST RESULTS - NATC

Colebrand
Thermal Shield Covers

(2 - 4 MARCH 1991)

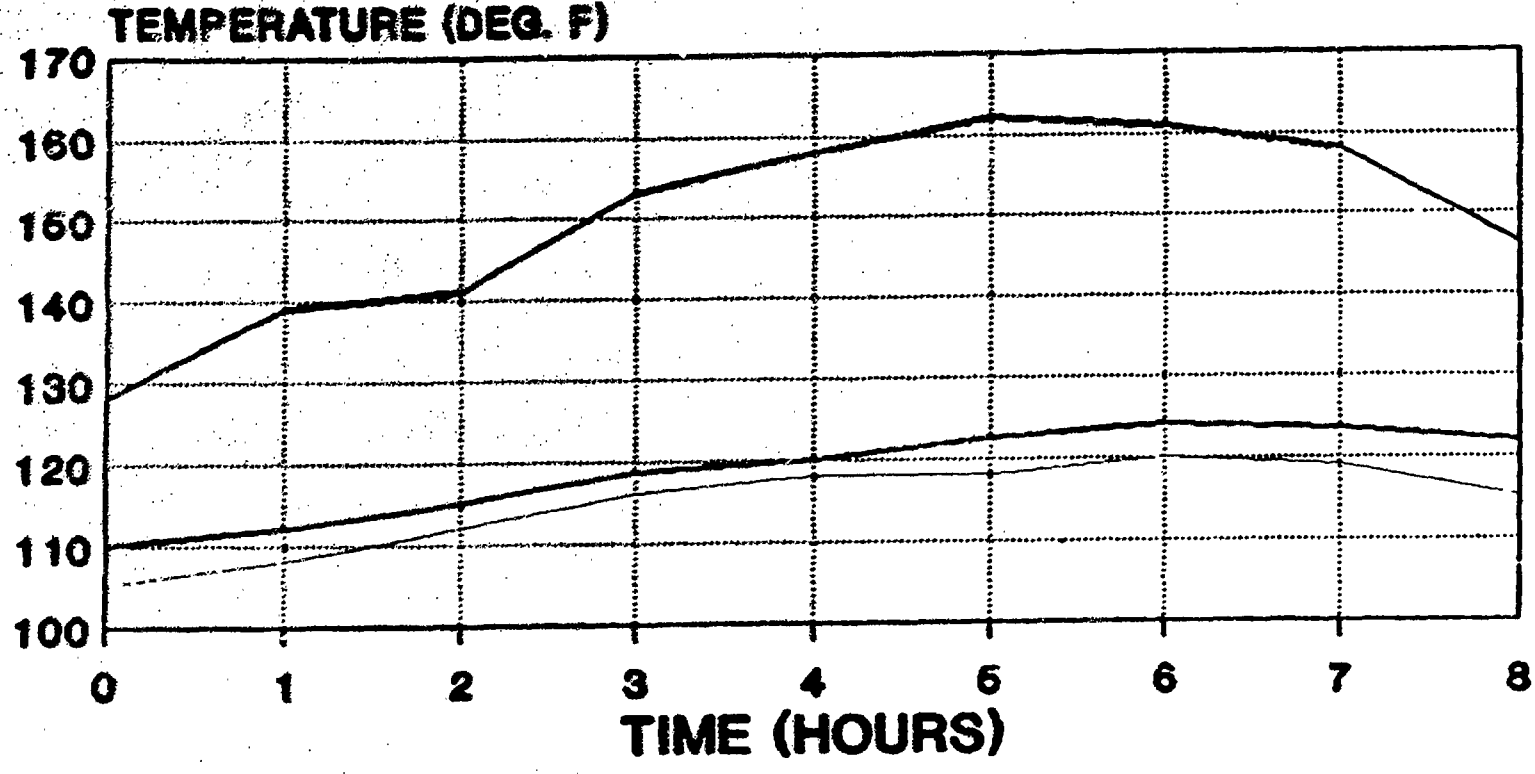
- **F/A-18**
  "The Results of the Thermal Protection Tests on the Canopy Cover Show That a Significant Degree of Cockpit Cooling is Obtainable With the Cover Installed Compared to a Cockpit/Canopy Without a Cover."
  Uncovered Canopy -- Ambient 110° F -- Canopy 180° F
  Covered Canopy -- Ambient 120° F -- Canopy 124° F

- **AV-8**
  "Thermal Effects Testing Indicated the Cover Provided Approximately 50° F Reduced Cockpit Temperature as Compared to a Closed Canopy Without the Cover."
  Uncovered Canopy -- Ambient 105° F -- Canopy 171° F
  Covered Canopy -- Ambient 105° F -- Canopy 120° F

TEST RESULTS - RARDE

Colebrand
Thermal Shield Covers

CHALLENGER MBT (TURRET, OUTER)

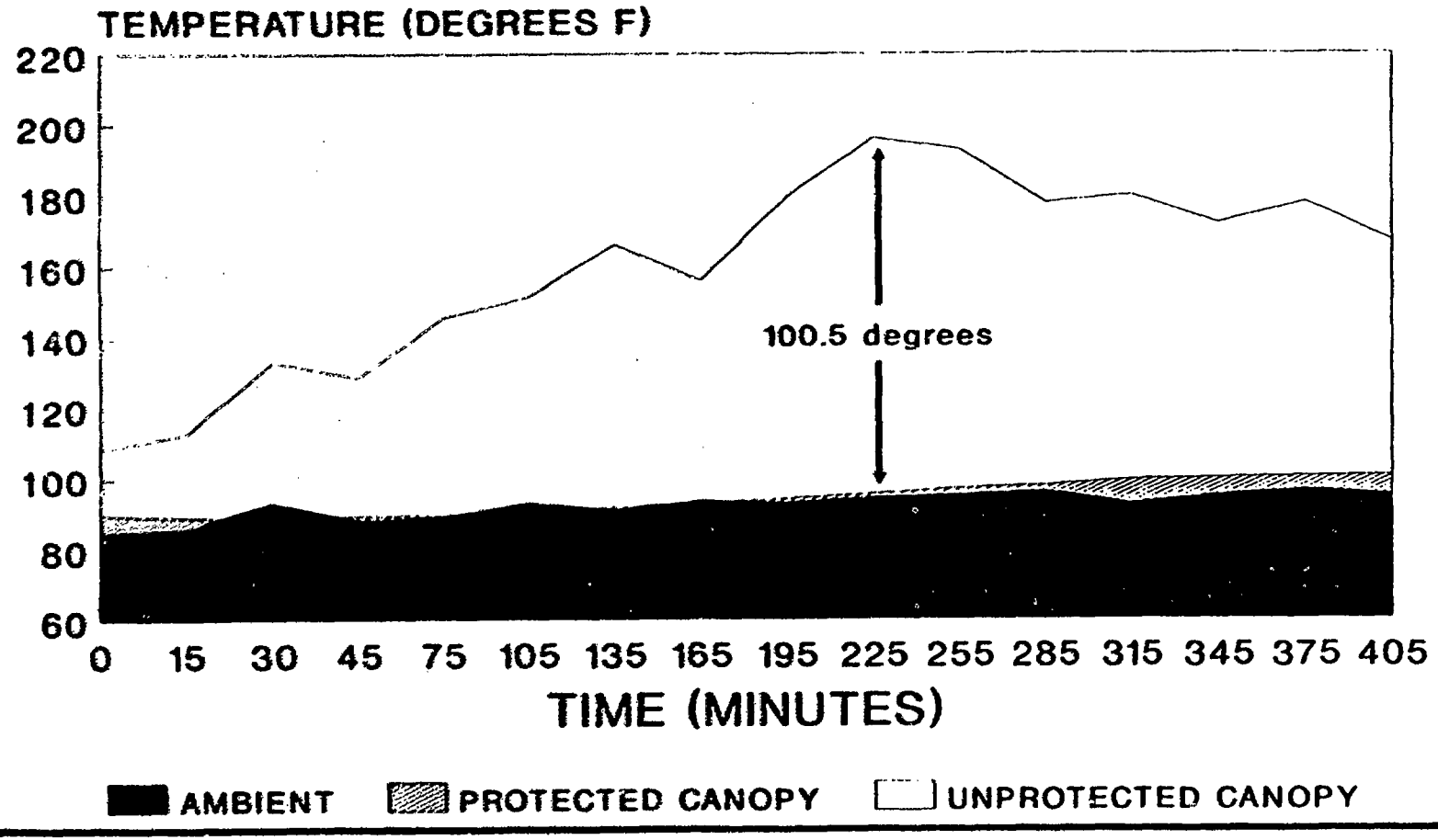


SOURCE: COLEBRAND HOUSE

TEST RESULTS

Colebrand
Thermal Shield Covers

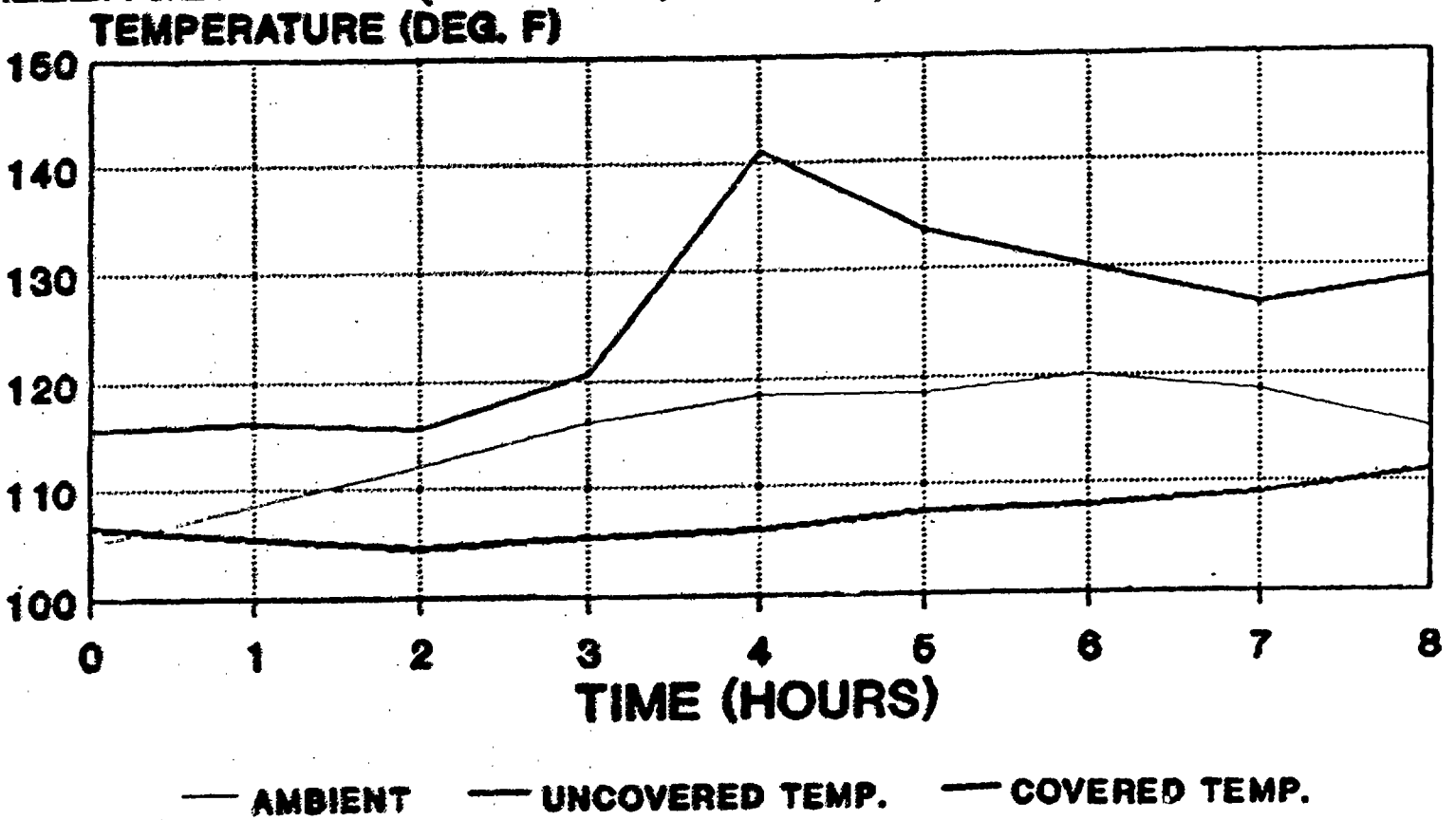
AV-8B Trial at MCAS YUMA - JUN 91



TEST RESULTS - RARDE

Colebrand
Thermal Shield Covers

CHALLENGER MBT (TURRET, INNER)

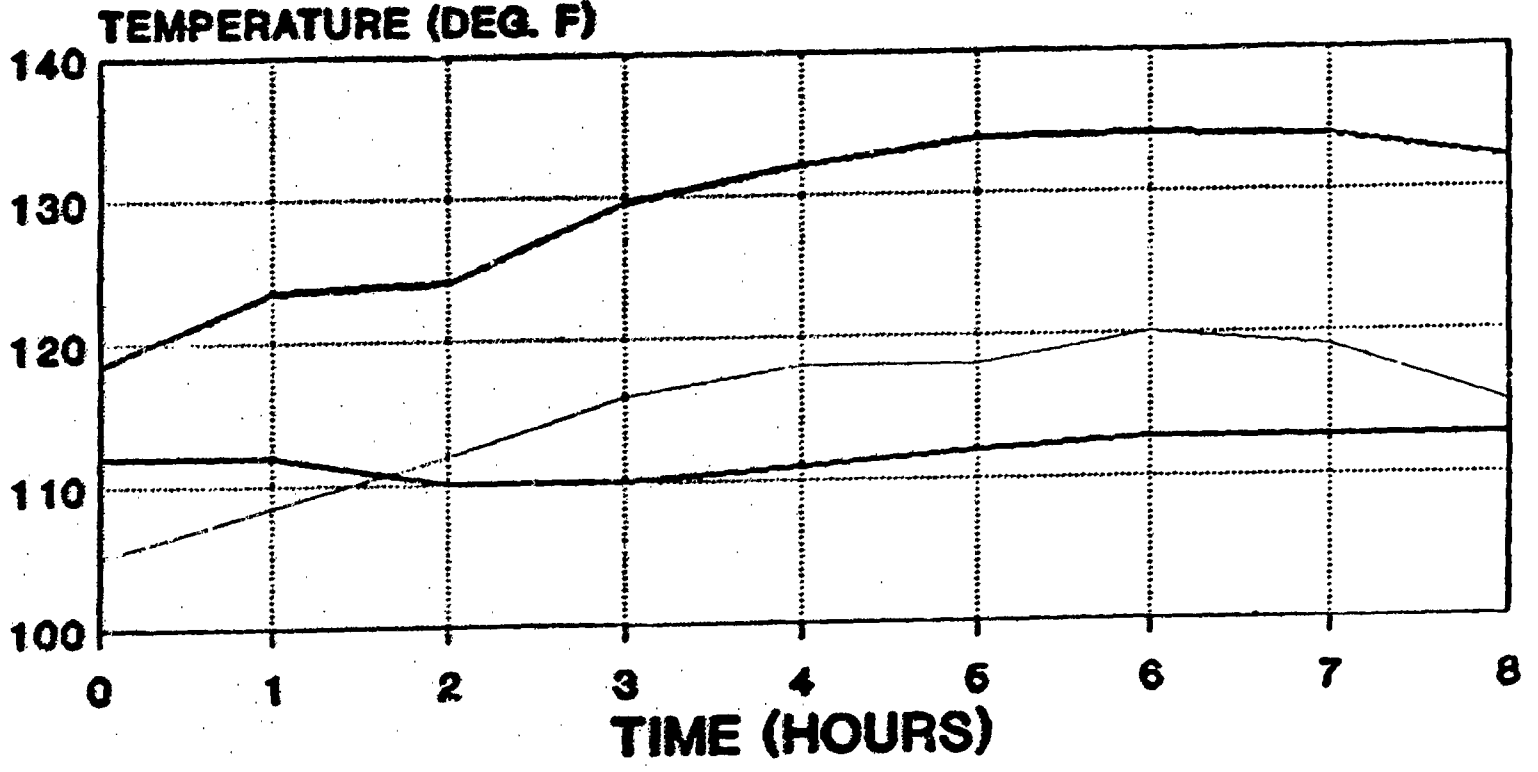


SOURCE: COLEBRAND HOUSE

TEST RESULTS - RARDE

Colebrand
Thermal Shield Covers

CHALLENGER MBT (INSIDE TURRET BUSTLE)



SOURCE: COLEBRAND HOUSE

TEST RESULTS - TACOM

Colebrand
Thermal Shield Covers

LIGHT ARMORED VEHICLE (LAV)

Tested at Cell #5 at TACOM in March:

- LAV Using M2/M3 Cover Tested Over 3 Hour Period
- Uncovered LAV Test Terminated After 3.5 Hours Because Inside Temperature Reached 225° F - Concern for Electronics and Other Equipment

CONCLUSIONS

Colebrand
Thermal Shield Covers

- Colebrand's Unique Heat Shield Material Is Ready to Protect Valuable and Vulnerable Assets, Storage Containers, and Work Areas
- Hot Weather Started in April in SWA and Equipment Must Be Protected to Avoid Costly Sparing and Repair
- Our Vehicles and Equipment at Training Sites in the U.S, and in Other Countries are in Need of Thermal Shield Material Year Round to Reduce Maintenance Costs and Increase Training Time
- Pre-positioned Equipment Should be Equipped with Thermal Shield Covers -- Areas of Likely Action Cluster Around the Equator

SUMMARY

Colebrand
Thermal Shield Covers

- Demonstrated Excellent Solar Protective Capability (50 - 70° F) in SWA, at Nellis AFB, and in Chamber Tests at NATC and TACOM and 100.5° F at the MCAS, Yuma, Arizona
- Long Lasting, Form-fitting, Affordable
- Waterproof, Oil and Fuel Resistant, and Flame Resistant. IR Protection Optional, Testing Needed
- Provide Protection to Aircraft Windscreens from Sand and Adverse Weather Damage
- Ready for Procurement in Any Quantities